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The Use of the Land Command and Control Information Exchange Data Model in Virtual Battle Experiment – Bravo

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Defence R&D Canada

Technical Memorandum
DRDC Atlantic TM 2004-002
March 2004

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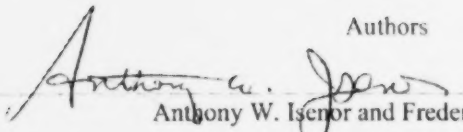

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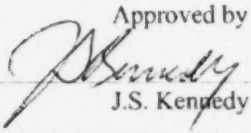

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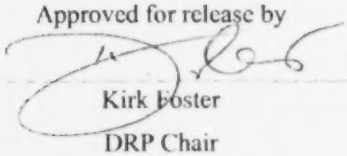

Kirk Foster

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Abstract

Virtual Battle Experiments (VBE) provide a simulation environment for the testing of algorithms and operating procedures. When multiple platforms are included in the simulation, communication between platforms can also be investigated. For example, when certain data and information are shared between platforms, the result may be the more efficient completion of the simulated mission. In a naval setting, such information may include contact data within the area of operation. However, for this data sharing to take place, the virtual platforms need to reach an agreement on the data structure and content. Research under the auspices of The Technical Cooperation Program, Maritime Systems Group, Technical Panel – One, is investigating the use of the Land Command and Control Information Exchange Data Model (LC2IEDM) for the sharing of data between virtual platforms. This investigation details the data storage within LC2IEDM during VBE-Bravo, conducted in April 2003. For the experiment, the data stored within LC2IEDM includes initial information on the coalition forces, information on enemy forces, and discovered contacts.

Résumé

Les expériences de combat virtuel (VBE) constituent des environnements de simulation pour la mise à l'essai d'algorithmes et de procédures opérationnelles. Lorsque plusieurs plates-formes font partie d'une simulation, il est aussi possible d'étudier les communications entre plates-formes. Par exemple, lorsqu'il y a partage de certaines données et de certains renseignements entre plates-formes, cela peut mener à une exécution plus efficiente de la mission simulée. Dans un milieu naval, l'information échangée peut comprendre des données sur les contacts dans la zone d'opérations. Toutefois, pour qu'il y ait partage des données, il doit y avoir entente entre les plates-formes virtuelles au sujet de la structure et du contenu des données. Des recherches menées sous les auspices du Comité technique 1 du Groupe d'analyse des systèmes de marine du Programme de coopération technique (TP-1 MAR TTCP) portent sur l'utilisation du modèle de données d'échange d'information de commandement et de contrôle (Terre) (LC2IEDM) en vue du partage de données entre plates-formes virtuelles. La présente étude décrit en détail le stockage des données dans le LC2IEDM durant la VBE Bravo, menée en avril 2003. Aux fins de l'expérience, les données stockées dans le LC2IEDM comprenaient l'information initiale sur les forces de coalition, l'information sur les forces ennemies et les contacts détectés.

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Executive summary

Introduction

Virtual Battle Experiments (VBEs) are being utilized as a mechanism to investigate a variety of topic areas important to the navy. The virtual environment provides a cost effective mechanism for testing algorithms (e.g., target motion analysis) and operating procedures. Such an environment is also well suited to investigate the sharing of data and information between the virtual platforms.

In this investigation, the data sharing between virtual platforms utilizes a central data structure. The structure, which is the Land Command and Control Information Exchange Data Model (LC2IEDM), is an international army-based effort that has developed from the Army Tactical Command and Control System (ATCCIS) programme which originated in the 1980s. LC2IEDM provides an extensive set of attributes and rules for sharing planning and operational data.

Such sharing is important within a coalition mode of operation. Sensors on remote platforms may be used to collect data within the sensors field of reach. By sharing the collected data among the coalition platforms, the effective area of reach of any one platform is expanded. The LC2IEDM may be used as the common structure through which data is exchanged between these platforms.

This report details the use of LC2IEDM in a virtual battle experiment. The experiment, conducted under the auspices of The Technical Cooperation Program, considers the sharing of information between a submarine and two surface ships. Although full two-way data communications was not available during the VBE, the report details the one-way data placement into the LC2IEDM during the VBE.

Principal Results

This investigation provides detailed documentation on the use of the LC2IEDM within a naval virtual battle experiment. The report details the data placement within LC2IEDM and highlights the types of data that would be important for sharing in a networked coalition task group.

Significance of Results

The LC2IEDM is being promoted as a possible solution to the network-based sharing of data. Although LC2IEDM has its origin in the army, the system is being considered for joint operations. This report provides a preliminary link between a naval tracking operation within a virtual simulation and the LC2IEDM. This link is important

because it provides the army-based LC2IEDM community with a naval perspective on the components of the model that may be used in a naval operation. As well, the naval community is provided with a template for the data sharing that is possible using the LC2IEDM. Finally, the naval research community benefits from an understanding of LC2IEDM structures and how joint operations may use such a structure for the data sharing requirements of a networked military.

The work presented here is also important for those considering the use of the LC2IEDM in future research and development. The investigation supports national efforts, such as the Networked Underwater Warfare (NUW) Technology Demonstration Project currently underway at Defence R&D Canada – Atlantic. NUW intends to use a virtual environment in algorithm and communication tests before sea trials. This work provides background information on how LC2IEDM might fit into such tests.

Future Plans

There are many potential avenues for future investigation. The extensibility of the LC2IEDM for specific naval applications needs to be explored. This activity will support those navy-specific data types that could be useful in a networked environment. Such an investigation would contribute to the Networked Underwater Warfare Technology Demonstration Project currently underway at Defence R&D Canada – Atlantic and the TTCP efforts in Virtual Battle Experiments.

Part of the extensibility testing also needs to consider the replication between instances of the LC2IEDM. This type of investigation could involve a collaborative effort between DRDC Atlantic and DRDC Valcartier. Such collaboration would establish positive linkages between the army and navy areas of research.

Isenor, Anthony W. and Frederick G. Burkley. 2004. The Use of the Land Command and Control Information Exchange Data Model in Virtual Battle Experiment – Bravo, DRDC Atlantic TM 2004-002. Defence R&D Canada – Atlantic.

Sommaire

Introduction

Les expériences de combat virtuel (VBE) servent à l'étude de toute une gamme de questions importantes pour la Marine. L'environnement virtuel constitue une solution rentable de mise à l'essai d'algorithmes (p. ex. l'analyse des mouvements des cibles) et de procédures opérationnelles. Un tel environnement convient bien à l'étude du partage de données et d'information entre plates-formes virtuelles.

Dans la présente étude, des données présentées selon une structure commune sont partagées entre plates-formes virtuelles. Cette structure, le modèle de données d'échange d'information de commandement et de contrôle (Terre) (LC2IEDM), est le fruit d'un effort militaire international déployé dans le cadre du programme du système tactique d'information de commandement et de contrôle de l'armée de terre (ATCCIS), lancé dans les années 1980. Le LC2IEDM comporte une série exhaustive de règles et d'attributs pour le partage de données opérationnelles et de planification.

Un tel partage joue un rôle important dans le mode de fonctionnement en coalition. Des capteurs posés sur des plates-formes éloignées peuvent servir à la collecte de données dans la zone de portée des capteurs. Grâce au partage des données recueillies par les plates-formes de coalition, la zone de portée effective de n'importe quelle plate-forme est élargie. Le LC2IEDM peut servir de structure commune pour l'échange de données entre plates-formes.

Le présent rapport décrit en détail l'utilisation du LC2IEDM dans une VBE. L'expérience, menée sous les auspices du Programme de coopération technique (TTCP), portait sur le partage d'information entre un sous-marin et deux navires de surface. Même si la transmission de données entièrement bidirectionnelle n'était pas disponible durant la VBE, le rapport décrit en détail le stockage unidirectionnel de données dans le LC2IEDM durant la VBE.

Résultats

La présente étude comporte une documentation détaillée sur l'utilisation du LC2IEDM dans une expérience de combat virtuel naval. Le rapport décrit en détail le stockage des données dans le LC2IEDM et fait ressortir les types de données qu'il serait important de partager dans un groupe opérationnel de coalition en réseau.

Portée

On fait la promotion du LC2IEDM comme solution possible en vue du partage de données en réseau. Même si le LC2IEDM provient à l'origine de l'Armée de terre, le modèle est considéré pour des opérations interarmées. Le présent rapport établit un lien préliminaire entre une opération de poursuite navale dans une simulation virtuelle et le LC2IEDM. Il est important d'établir un tel lien parce que cela donne aux utilisateurs du LC2IEDM de l'Armée de terre une perspective navale sur les composants du modèle susceptibles d'être utilisés dans une opération navale. En outre, un modèle est fourni au milieu naval pour le partage des données qu'il est possible de réaliser grâce au LC2IEDM. Enfin, le milieu de la recherche navale bénéficie d'une compréhension des structures du LC2IEDM et de la façon dont les opérations interarmées pourraient utiliser un tel système pour les besoins de partage de données des militaires en réseau.

Le travail décrit aux présentes est également important pour ceux qui envisagent la possibilité de se servir du LC2IEDM dans de futurs travaux de recherche et développement. L'étude vient à l'appui des efforts nationaux, comme le projet de démonstration de technologie de guerre sous-marine en réseau (NUW), en cours à R & D pour la défense Canada – Atlantique. Ce projet vise le recours à un environnement virtuel durant les essais des algorithmes et des communications avant les essais en mer. Le présent travail fournit des renseignements généraux sur la façon dont le LC2IEDM pourrait être intégré à ces essais.

Recherches futures

Il y a de nombreuses possibilités de recherches futures. La possibilité d'étendre le LC2IEDM à des applications navales précises doit être explorée. Cette activité prendra en charge les types de données propres à la Marine qui pourraient se révéler utiles dans un environnement en réseau. Une telle étude contribuerait au projet de démonstration de technologie de NUW, en cours à R & D pour la défense Canada – Atlantique, et aux efforts sous les auspices du TTCP dans le cadre des VBE.

Une partie des essais sur les possibilités d'extension doit également tenir compte des cas de dédoublement dans le LC2IEDM. Ce type d'étude pourrait donner lieu à un effort de collaboration entre RDDC Atlantique et RDDC Valcartier. Une telle collaboration permettrait d'établir des rapports positifs entre les secteurs de recherche de l'Armée de terre et de la Marine.

Isenor, Anthony W. and Frederick G. Burkley. 2004. The Use of the Land Command and Control Information Exchange Data Model in Virtual Battle Experiment – Bravo, DRDC Atlantic TM 2004-002, Defence R&D Canada – Atlantic.

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1. Introduction

Military research has traditionally focused on the three main branches of the military establishment – army, air force and navy. Each branch has conducted research and development in subject areas that often combine the disciplines of physics, chemistry and mathematics to solve problems related to topics such as platform performance, combat or processing systems, and the sensing or detection of threats in an area of interest.

The early research efforts were labour intensive. As an example, consider early Canadian naval research, which concentrated efforts on ship degaussing [1] during World War II. Calculations were typically done with paper, pencil and a slide rule. The rise in computing power greatly impacted this type of research. Algorithms were coded in software, and the computers became our number processing machines.

The most obvious direct implication of computing power was in numeric processing. However, the influence of computers now encompasses all realms of research. Computers not only perform the mundane numeric processing but also model all aspects of the research from sensor development to large-scale platform performance. Computers have become ubiquitous throughout the research process.

As part of this expansion, computers are now being used to model entire operations. In such cases, computers are used for more than algorithm processing. In these cases, the computer provides a simulation of a complete environment. Such environments are often referred to as virtual environments.

In naval research, organisations have begun utilizing virtual environments. Researchers are using virtual ships to study a variety of issues involving algorithm development and communications. When researchers employ multiple virtual ships, platform communication issues may be investigated.

Of particular interest in many such investigations is the possible performance implications associated with multi-ship communications. In a multi-ship environment, the sharing of data and information between platforms may have implications on mission success or the speed to mission completion. Such network sharing of information is commonly referred to as network enabled capabilities (NEC) [2]. In the United States (US), a doctrine is developing around the use of the network. This doctrine is commonly referred to as net-centric warfare (NCW) [3].

In a virtual environment, the complicated issue of network sharing of data and information can be researched in a very cost-effective way. In the virtual environment, the researcher has complete control over all conditions. For example, there is no downtime due to poor weather, as is sometimes the case in sea trials. Researchers can also easily task a component of the virtual environment. A virtual ship can easily be assigned a task within a certain operational area.

Numerous countries are now using virtual environments as a research tool. For example, Australia (AS) has made considerable progress in modelling virtual submarines [4]. Through The Technical Cooperation Program (TTCP) Maritime Systems Group (MAR) Technical Panel – 1 (TP-1), much of this effort has been made available to member countries, including Canada (CA) and the US. New Zealand (NZ) has also conducted a virtual experiment, and the United Kingdom (UK) is presently planning an experiment.

In Canada, virtual experiments are now being planned and conducted at DRDC Atlantic [5]. These experiments are designed to explore the implications of additional information that may be made available in a networked environment [6, 7]. Although in the preliminary stages, these experiments use much of the infrastructure made available through TTCP relationships.

Internationally through TTCP, considerable effort has been directed towards virtual experiments that integrate and assess new algorithms for such tasks as target motion analysis and data fusion [8, 9]. Researchers develop new or improved algorithms, make these algorithms available to an operator in the virtual environment, and run a planned scenario that utilizes the new algorithm. Such experiments have typically taken the form of a virtual situation involving an encounter with enemy forces, or loosely a virtual battle. Thus, the investigations have been labelled Virtual Battle Experiments (VBEs).

VBEs involving more than one virtual coalition platform have the potential to investigate the sharing of data and information within the coalition force. In this case, the VBE can examine how the sharing of data and information can enhance or influence the actions of the coalition force. For example, TTCP VBEs are examining enhancements to picture compilation when platforms share information. As well, efforts are underway to perform the data analysis necessary to quantify any picture compilation benefits [10].

An important point in any investigation examining information sharing is the type of information being shared. In the international VBEs, one component of the experiment is examining the data storage capabilities of the Land Command and Control Information Exchange Data Model (LC2IEDM). This data model is army based, and is now part of the NATO corporate data model [11].

The LC2IEDM is well documented in terms of system-level documentation [12, 13]. Recent investigations have also examined the LC2IEDM from the perspective of navy tactical data storage of contact data [14]. In the VBEs, the LC2IEDM is at present being used as a central storage location for information. In future VBEs, researchers hope to investigate the flow of information through the LC2IEDM between the many coalition platforms within the virtual environment.

It should be noted that the LC2IEDM was initially known as the Generic Hub (GH) data model. Many organisations still refer to the model as the Generic Hub. This name originated from the concept of having a generic data model for multipurpose

operations that would form a hub for new system development [12]. The name was changed in 1999 to the LC2IEDM to better describe its function.

Recent efforts to address joint operations have further evolved the name to Command and Control Information Exchange Data Model (C2IEDM). However, the data model firmly has its origin in the army. Such data-space expansion into joint operations is not without controversy. Some suggest the data model is presently too large and complex, and should not be expanded toward joint operations [15].

Although the core functions of Generic Hub, LC2IEDM and C2IEDM are similar, they are nevertheless different data models. In the following report, we have used the LC2IEDM. We shall refer to both the data model and the database as LC2IEDM.

1.1 Outline of the Report

This document presents an investigation of data placement in the LC2IEDM in support of a VBE. The VBE data placement in the LC2IEDM database will illustrate various points. First, it will provide the reader with an understanding of the relationships within the model. The LC2IEDM has an extensive table and relationship structure and may appear overly complicated to many readers. However, the report will attempt to minimize the complexity by stepping through the data insertion into the LC2IEDM in a progressive manner, documenting the actual data insertion and why it is required for the LC2IEDM structure. Hopefully, this will reduce the complications for the reader.

The second point to consider is the documentation associated with the model. Any insertion of data into a previously unknown data model will test the accompanying documentation. The LC2IEDM has extensive and often complicated relationships. This means the documentation must be capable of presenting these complications to a generally uninformed reader.

Considerable documentation already exists for the LC2IEDM [12, 13, 16, 17, 18, 19]. This report is somewhat different from the other LC2IEDM documentation in that this report details the insertion of data particular to the VBE, into the LC2IEDM. The report will explain only those tables used during the insertion. In this regard, this report is application specific, and is not general documentation for the LC2IEDM.

1.2 Syntax of the Report

Throughout this report, considerable nomenclature will be used to describe the structure of the data model. The LC2IEDM database tables will be denoted in uppercase characters (e.g., OBJ_ITEM). The LC2IEDM table column names will also be uppercase. Note that columns will be associated with tables, and thus the physical implementation of the data model. The logical model will be described using entities

and attributes in place of the physical model tables and columns. The logical model entity and attribute names will be identified in italic font, with a single dash separating the words that comprise the name (e.g., *object-item*). Although not exactly correct, we will refer to table names using the logical model names. We hope this will improve the readability of the report.

The LC2IEDM system will also be described using both the data model and the database. The two (data model and database) are different, as you cannot place data into a data model. The data model is the blueprint for the construction of the database. However, for the purpose of this report both the data model and database will be referred to as LC2IEDM.

Finally, we will use the eXtensible Markup Language (XML) to input data into the LC2IEDM. In this report, XML tags will be denoted in the text including the angle brackets <>. This should uniquely identify an XML tag name from a database column name in those cases where the two are the same. The content of the XML tag will be identified using double "quotes" with the actual content in Arial font (e.g., "5").

The XML will be used to identify the LC2IEDM tables and records. An XML tag containing the suffix "_TBL>" will be used to indicate the table being loaded. For example, the tag <REF_TBL> identifies the REF table. An individual record in the database table will be identified with an XML tag containing only the table name. For example, the tag <REF> indicates the start of a record to be loaded to the REF table.

2. System Components

There are many software components being utilized in this investigation. The databases form only a part of the system. The following provides a brief introduction to the main software components. The introduction is not intended to convey the details of using or implementing these components. Rather, it is intended to provide an overview of the important components for this investigation.

2.1 ERwin™

ERwin™ is an entity-relationship modelling software package developed by Computer Associates [20]. The LC2IEDM is available in the ERwin™ format, version 3.5.2. The ERwin™ software used during this investigation was version 4.1.2522.

ERwin™ has been used for the full LC2IEDM development cycle. The software provides a graphical user interface to allow the user point-and-click model design capabilities. Entity and relationship properties are quickly accessible. As well, ERwin™ provides a domain dictionary for the creation and management of entities and relationships.

ERwin™ also provides the database design generation. This means that ERwin™ can generate the necessary Structured Query Language (SQL) commands to create the actual database from the model.

There are two important features that make the data modelling software important for this investigation. First, the software allows the visualization of the data model. This is particularly important when attempting to understand the relationships between entities. As well, the user may define the level of complexity in the visualization. This means that areas of the data model may be isolated and visualized without considering the entire model. The LC2IEDM data model diagrams presented in this report are from the ERwin™ software.

Second, ERwin™ allows quick search and selection of entities, attributes, and relationships. This can save considerable time as compared to searching multiple volumes of documentation to identify all the characteristics of a particular entity, attribute or relationship.

2.2 Land Command and Control Information Exchange Data Model

LC2IEDM data model defines standard elements of information. These elements are considered the basis for interoperability between those automated NATO national Command and Control Information Systems (C2ISs) that accommodate the model's information structure [12].

The NATO requirement was to define only the information that is to be exchanged, rather than model all of the information that would normally be required by a national system. Information exchange requirements will change over time, and for that reason there was a need to design a flexible generic model that could adapt over time to changing information needs as well as serve as a basis or hub for new national systems. For these reasons the data model was originally known as the Generic Hub (GH) Data Model.

The LC2IEDM data model can be broken down into three components:

- A Conceptual Data Model that represents the high level view of the information to enable senior staff to verify the scope of the information structure.
- The Logical Data Model is the core component that represents all of the information and is based upon breaking down the high level concepts into information that is regularly used. For example a submarine is a military maritime vessel that is a piece of equipment that is a piece of materiel. This breakdown follows human reasoning patterns. The model specifies the way information is structured using entity-attribute-relationship diagrams and supporting documentation.
- A Physical Data Model that defines the structure of the database, which currently consists of 196 tables and about 1200 fields within an Oracle database.

Both the physical and logical models are available in ERwin™ diagrams.

2.3 Oracle

Oracle™ [21] is a company specializing in information management software. The Oracle™ product line includes specialized software for database management, development tools, application server tools, collaboration suites and data warehousing tools. Oracle™ is reported to be the second largest software company in the world, with annual revenues of about 10 billion dollars [22] and a database market share of 39.4% [23].

The Oracle™ Company markets the Oracle™ database (hereafter, "Oracle" will refer to the database). The Lite version of the database is available for free download. Personal Oracle9i Release 9.2.0.1.0 (for the Win2000 PC) comes packaged with numerous application tools including the command line interface SQL Plus. The Oracle database is used in this LC2IEDM implementation.

SQL Plus provides command line functionality to standard SQL and extended functionality particular to Oracle. The software may be executed either via the windows menu system or from a DOS command window. Some useful SQL Plus commands are listed in Table 1. Documentation for SQL Plus is also available [24].

Table 1. Some commands for the SQL Plus command line interface to an Oracle database.

COMMAND	FUNCTION
help index	Obtain help on SQL Plus commands.
desc	List column definitions for a table.
quit	Quit the command line interface.
@	Allows execution of script file.

2.4 Operational Context Exchange Service

The Operational Context Exchange Service (OCXS) is being developed by the Naval Undersea Warfare Center (NUWC) [25] in the US to provide a coalition data server and supporting services based upon the NATO-developed LC2IEDM. OCXS is a Java software suite designed to act as a bridge between the LC2IEDM and outside applications.

The OCXS suite utilizes logical and physical XML tag sets based on the logical and physical name sets used in the ERwin™ LC2IEDM model. The logical name set used by OCXS duplicates the naming convention used in the LC2IEDM logical model. The physical name set duplicates the naming convention used in the LC2IEDM physical model. Note that the physical model corresponds to the tables and field names used in the actual Oracle implementation of the LC2IEDM.

Data may be input to the LC2IEDM using OCXS and the physical XML name set. If data exist using the logical name set, a converter is provided to transform the logical to physical name sets. This transformation is performed using eXtensible Stylesheet Language Transformations (XSLT). A brief introduction to XSLT is presented in [26].

OCXS inputs the data to the LC2IEDM using the physical XML name set. All relationships within the LC2IEDM are dealt with implicitly from the data file. The initial OCXS implementation did not deal with any LC2IEDM relationships. This

means that the input XML document must load the LC2IEDM tables without violating any formal relationships in the LC2IEDM.

Note that subsequent OCXS revisions provide an object oriented message interface to LC2IEDM. These object-based messages generate appropriate XML documents for input to LC2IEDM.

OCXS also deals with output from the LC2IEDM. OCXS can request information from the LC2IEDM, with the information being made available to the user as a physical XML tag set. If desired, this physical tag set can be converted to a logical tag set via an XSLT transform. The OCXS output mechanism was not utilized during this investigation.

The OCXS Service employs a three-tier architecture shown in Figure 1, consisting of the following software components:

- Communications (Comms) Library – This is the client tier Application Programming Interface. The Comms Library allows clients (producers and consumers, described below) to send messages to and retrieve them from the Server Tier of the OCXS Service.

- Application Server – The server tier communicates with the Comms Library and the backend LC2IEDM database. This tier presently consists of two Java Servlets; one Servlet handles producer messages (Producer Servlet) and the other handles consumer messages (Consumer Servlet).

- Database – The LC2IEDM Version 5 database.

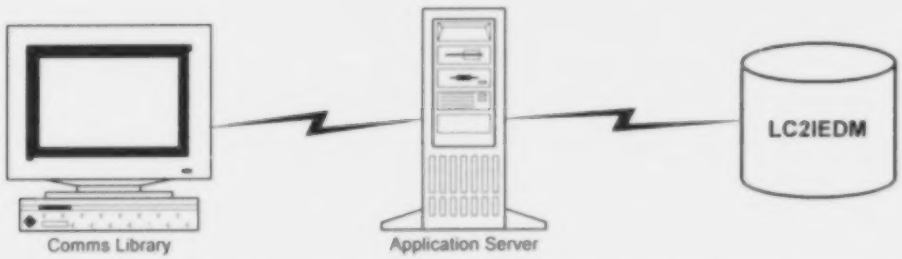

Figure 1. OCXS Service architecture consists of three tiers: the Communication library, the application server and the database.

The current version of the OCXS software library delivered by NUWC now supports the following functionality:

- An Application Server that populates LC2IEDM via the ingestion of XML messages. This is a generic service that will write any conformant XML

message to the database. A conformant XML message is a message that uses the LC2IEDM physical name set and adheres to the formal relationships mandated by LC2IEDM (i.e., matches the physical database schema and honors referential integrity constraints).

- A client tier Application Programming Interface (API) supporting XML message transmission.

- A set of objects that facilitate XML message generation and ingestion. Support currently exists for unit position report and track messages. For example, a unit position report object knows how to generate the XML message corresponding to a unit position report (a self report of latitude / longitude position). This facilitates the use of the LC2IEDM data model without a rigorous understanding of all of the model's formal relationships.

- Support for high-level unit position and track attribute requests. This attribute message gives clients high-level summary information about platforms within LC2IEDM. This message allows clients to determine which platforms are of sufficient interest to warrant further investigation.

- Support for detailed unit position and track requests. This message gives clients the latest attribute, positional and kinematic information about platforms within LC2IEDM. Attribute information such as platform threat, positional information such as latitude / longitude, kinematic information such as course and speed.

2.4.1 OCXS Service Architecture in VBE-B

For VBE-B, all three components of the OCXS Service were deployed on a single system; a Gateway laptop with a 2 Gigahertz Pentium 4 processor, 512 Megabytes of RAM and a single 30 Gigabyte IDE disk drive (5400 RPM). The OCXS Gateway Federate was also deployed on that system. This was done for ease of configuration.

This simplified architecture removed two sources of delay for OCXS messages. There was no external network delay from the Comms Library to the Application Server and no external network delay from the Application Server to the database. Conversely, all processes shared the same CPU.

2.4.2 Producer Message Processing

This Section details the processing stages of producer messages. There are two types of producer messages: Unit Position Reports and Solution Reports.

Unit Position Reports detail the present position of the reporting object. This is a self-report on the location of the reporting platform.

The Solution Report deals with the information on a contact. The processing pipeline is the same for each message type.

We now detail the sequence of events that occurs when a producer generates a message for the OCXS Service. This message (Unit Position Report or Solution Report) is created in the client tier, passed to the Application Service tier, then passed to the database tier. The final result is the entry of the message into the LC2IEDM database.

As will be seen, stylesheet processing occurs in the client tier, SQL generation and transmission occurs in the Application Service tier, and the database write occurs in the database tier.

The following processing occurs in the client tier:

- An object (representing a producer message) is passed into the Comms Library.
- An XML message is generated. This message conforms to the logical schema of the LC2IEDM (Version 5) data model.
- An XSLT stylesheet is applied, transforming the message to conform to the physical schema of the LC2IEDM (Version 5) data model.
- The (transformed) XML message is transmitted to the Producer Servlet (Application Server).

The following processing occurs in the producer tier:

- The XML message is received and parsed via a Simple API for XML (SAX) parser.
- Each element in the message is transformed into a SQL insert statement. It is possible to achieve this in a generic fashion, since the XML message conforms to the physical schema of the LC2IEDM (Version 5) data model.
- Each SQL statement is submitted to the database engine via Java Database Connectivity (JDBC).

The following processing occurs in the database tier:

- The database performs the inserts. An exception is thrown if necessary. For example, an exception would result in a load that violates a relationship in the database.

This is illustrated in Figure 2.

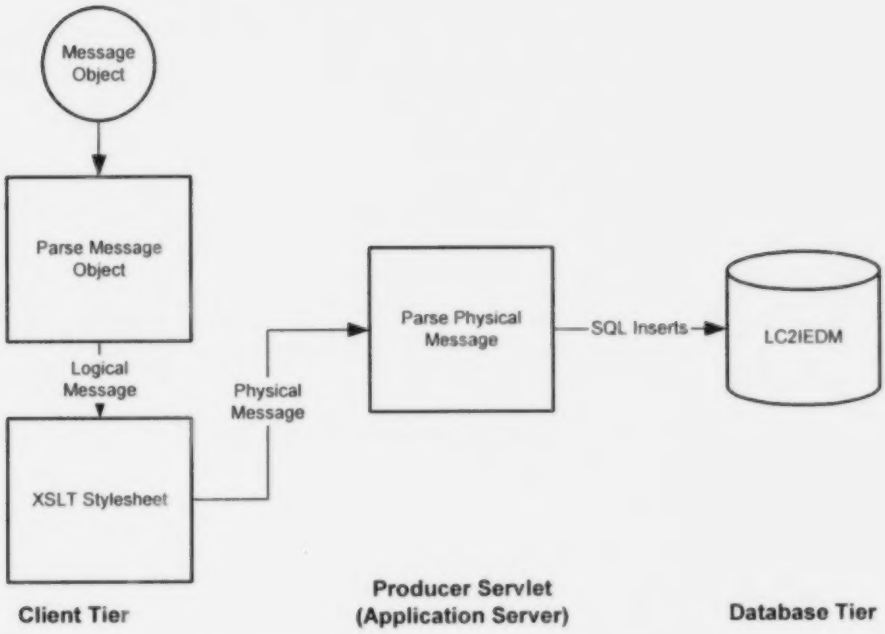

Figure 2. The OCXS producer message processing pipeline.

3. Virtual Battle Experiment

A Virtual Battle Experiment is a lab-based simulation, where operators are immersed in a synthetic environment. Operators are provided with a suite of tactical applications that are used to respond to the evolving scenario. The simulation environment is common to all VBEs and as such, allows the easy incorporation of national applications. This allows individual countries the flexibility to conceive, develop and integrate applications important to their national research objectives.

One focus of the VBE is to provide an environment for the testing of NEC. The virtual environment provides the flexibility to test both the specific and broad aspects of the experiment. In terms of specifics, a VBE may examine the details of a tactical application, in terms of performance or applicability to situations. In a broad capacity, a VBE may examine the picture compilation, which encompasses the numerous applications and complex interactions involving the operators.

Within the broad focus of NEC, VBEs also provide an excellent opportunity for the testing of information exchange requirements. Typically, VBE scenarios involve numerous platforms operating as a coalition group. In this respect, researching the information to be exchanged between the platforms is a valuable aspect of the experiment.

3.1 Scenario Description of VBE-Bravo

There were numerous objectives and hypothesis identified during the planning of VBE-B. In a summarized form, several objectives of the experiment concentrated on the integration and assessment of applications into the VBE infrastructure. In VBE terminology, these applications are called federates. The OCXS gateway federate was one of these applications [8].

The scenario for VBE-B outlined a coalition force involved in surveillance and reconnaissance activities off a foreign coast [8]. The force included two surface platforms, an unmanned aerial vehicle (UAV) and a submarine (see Table 2). The submarine represented the ownship of the VBE operators. Two hostile frigates[1] represented the red force. There were also numerous fishing and merchant vessels in the area of operation.

[1] The scenario description never indicated the actual number of hostile frigates. It is unclear how two hostile frigates were determined to be in the scenario. It may have been a direct result of the experiment being terminated after 30 minutes due to technical difficulties [10] and restarted on the following day.

For the experiment, the movement of all platforms except the submarine (named Sheean[2]) is completely scripted. The Sheean, which is ownship, has an initial course, speed and depth defined, but upon start-up of the experiment, the Commanding Officer is then in charge of the movements of the Sheean.

It should be noted that the UAV was not visible to any other platform in the scenario. The UAV was in effect a stealth unit. The addition of the UAV federate to the VBE was effectively testing the integration aspects of the federate. Further developments by New Zealand will enhance the federate, moving the UAV towards the full functionality of a maritime patrol aircraft.

Table 2. The platforms involved in VBE-B.

PLATFORM	DESCRIPTION
FFH1 (HMCS Halifax) (FFH indicates Frigate, Helicopter)	A friendly Halifax class frigate from Canada.
FFH2 (HMNZS Te Kaha)	A friendly Halifax class frigate from New Zealand.
Submarine (HMAS Sheean[2])	An Australian submarine, which is ownship.
Unmanned Aerial Vehicle (UAV)	A New Zealand-based UAV. This was a stealth observer unit that was not an active participant in VBE-B.
FFG1 Hostile Frigate (FFG indicates Guided Missile Frigate)	A hostile frigate known to be in the area.
FFG2 Hostile Frigate	A hostile frigate known to be in the area.
Merchant Vessels	Seven merchant ships were in the area. The exact number was not known at the start of the experiment.
Fishing Vessels	Two fishing vessels were in the area. The exact number was not known at the start of the experiment.

[2] In the VBE-B Experimental Plan, ownship was named vWaller. This was changed before the experiment to Sheean.

4. VBE-B Data Load to LC2IEDM

The data load for any VBE takes place in two conceptual parts. The first represents the known or initial state of the scenario. In this part, all known platforms and organisations are entered into the LC2IEDM database.

The second conceptual part actually represents numerous loads of similar structure and content. These loads are the positioning information associated with known platforms, and any reports of newly detected platforms. These loads account for the discovery of previously undetected platforms in the operational area.

In what follows, both conceptual parts of the data load will be explained in terms of the physical XML input for the OCXS. The various sections of the input XML will be described in order of occurrence. The contiguous XML document may be found in Annex 1.

4.1 Initial Load – Coalition Data

The initial data load contains the information pertinent to the platforms known or thought to be in the area. Based on the scenario description [8], the known platforms consist of the coalition force, two hostile frigates and an assortment of fishing and merchant vessels. In some cases, the particular vessels are not known, but the class of vessel in the area is known. For example, it is known that fishing vessels are in the area, but the exact location, number and vessel characteristics are not known.

4.1.1 Reference Information

The data load begins with the placement of reference information in the REF *(reference)* table of LC2IEDM. The reference information is shown in Figure 3. The reference is intended to allude to the source of the represented information in the LC2IEDM [12].

The *reference-id* (<REF_ID>) shown in Figure 3 is a unique numeric identifier for the record. The *format-code* indicates the specific formatting of the referenced information. For example, the original information source may have been in the form of the NATO Allied Data Publication – 3 format (ADatP-3) version 11. In this case, the *format-code* would indicate that the original message was ADatP-3 version by using the code "AP3V11". In the load used for VBE-B, the format code of "NOS" indicates that the format is not otherwise specified [13].

The *descriptive-text* and the *source-text* fields are unformatted character string fields. In the VBE-B load, these fields identify that MAR TP-1 is conducting the VBE and that OCXS is being used in the data fill. The *security-classification* of the reference is "NU" indicating NATO unclassified [13]. The *transmission-type* code indicates the type of incoming transmission where the information originated. The code "EMLMSG" indicates that the information originated in an email message [13].

```
<?xml version="1.0" encoding="UTF-8"?>
<GH5Complete xmlns:dt="urn:schemas-microsoft-com:datatypes">
<REF_TBL>
    <REF>
      <REF_ID>1800000000</REF_ID>
      <FORMAT_CODE>NOS</FORMAT_CODE>
      <DESCR_TXT>MAR TP-1 VBE-B OCXS Data Fill</DESCR_TXT>
      <SECURITY_CLSFC_CODE>NU</SECURITY_CLSFC_CODE>
      <SOURCE_TXT>Scenario 1.xml</SOURCE_TXT>
      <TRANS_TYPE_CODE>EMLMSG</TRANS_TYPE_CODE>
      <OWNER_ID>1</OWNER_ID>
      <UPDATE_SEQNR>1</UPDATE_SEQNR>
    </REF>
  </REF_TBL>
```

Figure 3. The reference table is the first table to be filled in the data load. This table represents a reference to the information source used in the reporting.

4.1.2 Coalition Objects

The next data to be loaded pertains to the objects known by the coalition forces. These objects are identified by information in the OBJ_ITEM *(object-item)* table. In LC2IEDM, object items are made up of individually identifiable objects that have military significance. The objects must fall into one of the following categories: a facility, a feature, materiel, an organisation or a person [12].

For this description, the data load is broken into two parts. Part one is represented in Figure 4 and describes individual materiel units in the battlespace. For the VBE, these units are represented by the various platforms known at the start of the experiment. The known platforms include the coalition surface ships TeKaha and Halifax, the submarine Sheean and the UAV. For each unit, the <CAT_CODE> *(category-code)* indicates the objects are materiel.

The scenario also contains two hostile patrol frigates. These are indicated in Figure 4 by the two records containing the <NAME> "FFG1" and "FFG2". Based on the scenario description, the platforms (or object items in LC2IEDM terminology) are known to be in the area, and therefore it is reasonable to include the items in the initial data load. Note that including the item at this stage simply recognises the possible existence of the item in the area of operation.

```
<OBJ_ITEM_TBL>
  <OBJ_ITEM>
    <OBJ_ITEM_ID>2800000000</OBJ_ITEM_ID>
    <CAT_CODE>MA</CAT_CODE>
    <NAME>TeKaha</NAME>
    <ALTN_IDENTIFIC_TXT/>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_ITEM>
  <OBJ_ITEM>
    <OBJ_ITEM_ID>2801000000</OBJ_ITEM_ID>
    <CAT_CODE>MA</CAT_CODE>
    <NAME>Sheean</NAME>
    <ALTN_IDENTIFIC_TXT/>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_ITEM>
  <OBJ_ITEM>
    <OBJ_ITEM_ID>2802000000</OBJ_ITEM_ID>
    <CAT_CODE>MA</CAT_CODE>
    <NAME>UAV</NAME>
    <ALTN_IDENTIFIC_TXT/>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_ITEM>
  <OBJ_ITEM>
    <OBJ_ITEM_ID>2803000000</OBJ_ITEM_ID>
    <CAT_CODE>MA</CAT_CODE>
    <NAME>Halifax</NAME>
    <ALTN_IDENTIFIC_TXT/>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_ITEM>
  <OBJ_ITEM>
    <OBJ_ITEM_ID>1801000000</OBJ_ITEM_ID>
    <CAT_CODE>MA</CAT_CODE>
    <NAME>FFG1</NAME>
    <ALTN_IDENTIFIC_TXT>FFG1</ALTN_IDENTIFIC_TXT>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_ITEM>
  <OBJ_ITEM>
    <OBJ_ITEM_ID>1801000001</OBJ_ITEM_ID>
    <CAT_CODE>MA</CAT_CODE>
    <NAME>FFG2</NAME>
    <ALTN_IDENTIFIC_TXT>FFG2</ALTN_IDENTIFIC_TXT>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_ITEM>
```

Figure 4. *The first series of records for the object-item table indicates the materiel units or platforms used within the VBE. This load includes friendly and hostile units, however, no distinction between friendly and hostile units is made at this time.*

The second series of records to be added to the *object-item* table pertain to organisational information (Figure 5). Organisations are indicated by the <CAT_CODE> "OR", which indicates "an object-item that is administrative or functional structure" [12]. In this experiment, the loaded organisations represent command structures used in the VBE.

```
<OBJ_ITEM>
  <OBJ_ITEM_ID>2805000000</OBJ_ITEM_ID>
  <CAT_CODE>OR</CAT_CODE>
  <NAME>FFH2 Command</NAME>
  <ALTN_IDENTIFIC_TXT/>
  <OWNER_ID>1</OWNER_ID>
  <UPDATE_SEQNR>1</UPDATE_SEQNR>
</OBJ_ITEM>
<OBJ_ITEM>
  <OBJ_ITEM_ID>2806000000</OBJ_ITEM_ID>
  <CAT_CODE>OR</CAT_CODE>
  <NAME>Sheean Command</NAME>
  <ALTN_IDENTIFIC_TXT/>
  <OWNER_ID>1</OWNER_ID>
  <UPDATE_SEQNR>1</UPDATE_SEQNR>
</OBJ_ITEM>
<OBJ_ITEM>
  <OBJ_ITEM_ID>2807000000</OBJ_ITEM_ID>
  <CAT_CODE>OR</CAT_CODE>
  <NAME>UAV Command</NAME>
  <ALTN_IDENTIFIC_TXT/>
  <OWNER_ID>1</OWNER_ID>
  <UPDATE_SEQNR>1</UPDATE_SEQNR>
</OBJ_ITEM>
<OBJ_ITEM>
  <OBJ_ITEM_ID>2808000000</OBJ_ITEM_ID>
  <CAT_CODE>OR</CAT_CODE>
  <NAME>FFH1 Command</NAME>
  <ALTN_IDENTIFIC_TXT/>
  <OWNER_ID>1</OWNER_ID>
  <UPDATE_SEQNR>1</UPDATE_SEQNR>
</OBJ_ITEM>
<OBJ_ITEM>
  <OBJ_ITEM_ID>2810000000</OBJ_ITEM_ID>
  <CAT_CODE>OR</CAT_CODE>
  <NAME>TP-1 Coalition Commander</NAME>
  <ALTN_IDENTIFIC_TXT/>
  <OWNER_ID>1</OWNER_ID>
  <UPDATE_SEQNR>1</UPDATE_SEQNR>
</OBJ_ITEM>
</OBJ_ITEM_TBL>
```

Figure 5 *The second series of records for the object-item table indicates the organisations within the VBE. Here, the command structures are identified.*

4.1.3 Materiel

The next part of the data load deals with the MAT *(materiel)* table. Materiel is one form of an object item. The *materiel* table is defined as "An OBJECT-ITEM that is equipment, apparatus or supplies of military interest without distinction as to its application for administrative or combat purposes"[12]. This indicates that the materiel record pertains to both friendly and hostile materiel units.

The *materiel* table is the first table encountered in the load that represents a specialization in the data model. Specializations are a form of business rule that may be included in entity-relationship (ER) modelling [27]. Specializations indicate the increased specific definition of an object. The enforcement of specializations is typically included in software systems used to interact with the database. In the LC2IEDM Canadian implementation, the enforcement of specializations is included at the API level used to interact with the database [28]. This API level is known as the Data Services Layer (DSL).

In the present case, the information indicated in *object-item* is further specified by the information in the *materiel* table. This may be illustrated by considering Figure 4 in conjunction with Figure 6. In Figure 4 we see the <OBJ_ITEM_ID> of "2800000000" representing the TeKaha platform. Also note that this information pertains to <CAT_CODE> of "MA" indicating materiel. In the *materiel* table, the same identifier value for the <MAT_ID> forms the link between the two records. The materiel record then describes the visual identifiers for the materiel unit. The first record, which pertains to information for the TeKaha, indicates the unit is "GREY". The <MARKING_CODE> content of "NOS" indicates that any markings are not part of the standard list available for this code. The standard list is: numbers, stripe, stripes, symbols, writing, or not known [13]. The <MARKING_COLOUR_CODE> indicates the colour of any identified markings. Again, "NOS" indicates, "the appropriate value is not in the set of specified values" [13].

Each of the coalition object items identified in Figure 4 are listed in Figure 6. This is because the characteristics of these platforms are known by coalition personnel and thus may be loaded into the database at the start-up of the experiment. Similar information on the hostile frigates is not known at start-up. This is because the coalition has no available information on the hostile frigates within the scenario description [8].

```
<MAT_TBL>
  <MAT>
    <MAT_ID>2800000000</MAT_ID>
    <SERIAL_NO_ID_TXT/>
    <LOT_IDENTIFIC_TXT/>
    <BODY_COLOUR_CODE>GREY</BODY_COLOUR_CODE>
    <MARKING_CODE>NOS</MARKING_CODE>
    <MARKING_COLOUR_CODE>NOS</MARKING_COLOUR_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </MAT>
  <MAT>
    <MAT_ID>2801000000</MAT_ID>
    <SERIAL_NO_ID_TXT/>
    <LOT_IDENTIFIC_TXT/>
    <BODY_COLOUR_CODE>BLACK</BODY_COLOUR_CODE>
    <MARKING_CODE>NOS</MARKING_CODE>
    <MARKING_COLOUR_CODE>NOS</MARKING_COLOUR_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </MAT>
  <MAT>
    <MAT_ID>2802000000</MAT_ID>
    <SERIAL_NO_ID_TXT/>
    <LOT_IDENTIFIC_TXT/>
    <BODY_COLOUR_CODE>WHITE</BODY_COLOUR_CODE>
    <MARKING_CODE>NOS</MARKING_CODE>
    <MARKING_COLOUR_CODE>NOS</MARKING_COLOUR_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </MAT>
  <MAT>
    <MAT_ID>2803000000</MAT_ID>
    <SERIAL_NO_ID_TXT/>
    <LOT_IDENTIFIC_TXT/>
    <BODY_COLOUR_CODE>GREY</BODY_COLOUR_CODE>
    <MARKING_CODE>NOS</MARKING_CODE>
    <MARKING_COLOUR_CODE>NOS</MARKING_COLOUR_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </MAT>
</MAT_TBL>
```

Figure 6. *The materiel table is a specialization of the object-item. The materiel indicates the colour markings of the materiel platforms listed in the object-item table. Only the coalition platform's markings are indicated in this figure, because no information is available on the markings of the hostile frigates.*

4.1.4 Organisations

The ORG *(organisation)* table (Figure 7) is another specialization of an object-item. The *organisation* table tracks and describes the organizations. In this VBE, the organizations are identified in Figure 5. Note that the <OBJ_ITEM_ID> in Figure 5 matches the <ORG_ID> from Figure 7. In the record for the organization table, the <CAT_CODE> of "UN" indicates a military unit. A military unit is defined as "A military ORGANISATION whose structure is prescribed by competent authority"[12].

In this particular case, only one organisation is given a name. The final record in Figure 7 identifies the Task Force (TF) TTCP Blue. This indicates that the coalition command structure has a nickname of "TF TTCP Blue".

```
<ORG_TBL>
  <ORG>
    <ORG_ID>2805000000</ORG_ID>
    <CAT_CODE>UN</CAT_CODE>
    <NICKNAME_NAME/>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </ORG>
  <ORG>
    <ORG_ID>2806000000</ORG_ID>
    <CAT_CODE>UN</CAT_CODE>
    <NICKNAME_NAME/>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </ORG>
  <ORG>
    <ORG_ID>2807000000</ORG_ID>
    <CAT_CODE>UN</CAT_CODE>
    <NICKNAME_NAME/>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </ORG>
  <ORG>
    <ORG_ID>2808000000</ORG_ID>
    <CAT_CODE>UN</CAT_CODE>
    <NICKNAME_NAME/>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </ORG>
  <ORG>
    <ORG_ID>2810000000</ORG_ID>
    <CAT_CODE>UN</CAT_CODE>
    <NICKNAME_NAME>TF TTCP Blue</NICKNAME_NAME>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </ORG>
</ORG_TBL>
```

Figure 7. The organisation table is another specialization of object item.

4.1.5 Military Units

The *organisation* table has identified the military units. These units are further described in the UNIT *(unit)* table. The *unit* table is one entity in an incomplete specialization definition for the *organisation* table. The other entity in the specialization is *convoy*.

The *unit* table content is shown in Figure 8. The <UNIT_ID> is linked back to the <ORG_ID> in Figure 7. Thus, the organization defined with identifier "2805000000" corresponds to the military unit "FFH2" which is the coalition frigate command organisation, as indicated by Figure 5. The remaining records in the *unit* table identify the command structures for the Sheean, UAV, FFH1 and the TTCP Commander.

```
<UNIT_TBL>
  <UNIT>
    <UNIT_ID>2805000000</UNIT_ID>
    <FORMAL_ABBRD_NAME>FFH2</FORMAL_ABBRD_NAME>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </UNIT>
  <UNIT>
    <UNIT_ID>2806000000</UNIT_ID>
    <FORMAL_ABBRD_NAME>Sheean</FORMAL_ABBRD_NAME>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </UNIT>
  <UNIT>
    <UNIT_ID>2807000000</UNIT_ID>
    <FORMAL_ABBRD_NAME>UAV</FORMAL_ABBRD_NAME>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </UNIT>
  <UNIT>
    <UNIT_ID>2808000000</UNIT_ID>
    <FORMAL_ABBRD_NAME>FFH1</FORMAL_ABBRD_NAME>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </UNIT>
  <UNIT>
    <UNIT_ID>2810000000</UNIT_ID>
    <FORMAL_ABBRD_NAME>CTFC TTCP Blue</FORMAL_ABBRD_NAME>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </UNIT>
</UNIT_TBL>
```

Figure 8. The unit table is part of an incomplete specialization of an organisation. For VBE-B each organisation is considered a military unit.

4.1.6 The Association Between Organisation and Materiel

Next, the relationship between organization and materiel is specified (Figure 9). This is done via the ORG_MAT_ASSOC *(organization-material-association)* table. Note that version 5.0 of the model contains this particular table, while version 5.3 does not.

The *organization-material-association* table indicates the relationship between an organisation and a materiel object. Here, the <SUB_ORG_ID> provides a link back to the *organisation* table. This link defines the subject (thus SUB) of the relationship. The <OBJ_MAT_ID> provides the link back to the object. In this way, the object is associated with a particular organisation. More than one association can exist, as one object can be part of more than one organisation.

In this particular load, all records have a <CAT_CODE> containing "CONTRL". The definition of this code is "A specific ORGANISATION controls an item of Materiel" [13].

4.1.7 Types of Objects

The object type information (see Figure 10) may be considered high-level metadata pertaining to the class of objects defined in the *object-item* table. One method of distinguishing the object item and object type is to remember that an object type cannot have an associated quantity. This is because object types are categories or classes of objects, while object items are actually countable objects.

The first part of the object-type load contains records that have <CAT_CODE> of "MA" indicating Materiel. The first record indicates a UK object as indicated by <NATIONALITY_CODE> of "UK". The object is named "Type45". This is the Daring Class destroyer planned to enter service in the UK in 2007.

The second record has <OBJ_TYPE_ID> of "3801000000" and accounts for the Australian Collins class submarine. The UAV is described in the third record, and is noted to be from New Zealand and of type Predator. The final record indicates the Canadian Halifax class Frigate. Note that both coalition ships are Halifax Class frigates.

The second part of the object type indicates the organisational units (see Figure 11). The <CAT_CODE> of "OR" is defined as "An OBJECT-TYPE that represents administrative or functional structures" [13]. These organisations represent the command structures associated with the platforms.

```
<ORG_MAT_ASSOC_TBL>
  <ORG_MAT_ASSOC>
    <SUBJ_ORG_ID>2805000000</SUBJ_ORG_ID>
    <OBJ_MAT_ID>2800000000</OBJ_MAT_ID>
    <ORG_MAT_ASSOC_IX>1</ORG_MAT_ASSOC_IX>
    <CAT_CODE>CONTRL</CAT_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </ORG_MAT_ASSOC>
  <ORG_MAT_ASSOC>
    <SUBJ_ORG_ID>2806000000</SUBJ_ORG_ID>
    <OBJ_MAT_ID>2801000000</OBJ_MAT_ID>
    <ORG_MAT_ASSOC_IX>1</ORG_MAT_ASSOC_IX>
    <CAT_CODE>CONTRL</CAT_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </ORG_MAT_ASSOC>
  <ORG_MAT_ASSOC>
    <SUBJ_ORG_ID>2807000000</SUBJ_ORG_ID>
    <OBJ_MAT_ID>2802000000</OBJ_MAT_ID>
    <ORG_MAT_ASSOC_IX>1</ORG_MAT_ASSOC_IX>
    <CAT_CODE>CONTRL</CAT_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </ORG_MAT_ASSOC>
  <ORG_MAT_ASSOC>
    <SUBJ_ORG_ID>2808000000</SUBJ_ORG_ID>
    <OBJ_MAT_ID>2803000000</OBJ_MAT_ID>
    <ORG_MAT_ASSOC_IX>1</ORG_MAT_ASSOC_IX>
    <CAT_CODE>CONTRL</CAT_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </ORG_MAT_ASSOC>
</ORG_MAT_ASSOC_TBL>
```

Figure 9. The organisation-materiel-association table establishes the relations between specific organisations and materiel. In this case, materiel belongs to specific organisations. This is indicated by the "controls" category-code value.

```
<OBJ_TYPE_TBL>
  <OBJ_TYPE>
    <OBJ_TYPE_ID>3800000000</OBJ_TYPE_ID>
    <CAT_CODE>MA</CAT_CODE>
    <DUMMY_IND_CODE>NO</DUMMY_IND_CODE>
    <NAME>Type45</NAME>
    <NATIONALITY_CODE>UK</NATIONALITY_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_TYPE>
  <OBJ_TYPE>
    <OBJ_TYPE_ID>3801000000</OBJ_TYPE_ID>
    <CAT_CODE>MA</CAT_CODE>
    <DUMMY_IND_CODE>NO</DUMMY_IND_CODE>
    <NAME>Collins</NAME>
    <NATIONALITY_CODE>AS</NATIONALITY_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_TYPE>
  <OBJ_TYPE>
    <OBJ_TYPE_ID>3802000000</OBJ_TYPE_ID>
    <CAT_CODE>MA</CAT_CODE>
    <DUMMY_IND_CODE>NO</DUMMY_IND_CODE>
    <NAME>PredatorNZ</NAME>
    <NATIONALITY_CODE>NZ</NATIONALITY_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_TYPE>
  <OBJ_TYPE>
    <OBJ_TYPE_ID>3803000000</OBJ_TYPE_ID>
    <CAT_CODE>MA</CAT_CODE>
    <DUMMY_IND_CODE>NO</DUMMY_IND_CODE>
    <NAME>Halifax</NAME>
    <NATIONALITY_CODE>CA</NATIONALITY_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_TYPE>
```

Figure 10. The first part of the object-type tables identifies the various classes of physical objects in the scenario.

```
    <OBJ_TYPE>
      <OBJ_TYPE_ID>3805000000</OBJ_TYPE_ID>
      <CAT_CODE>OR</CAT_CODE>
      <DUMMY_IND_CODE>NO</DUMMY_IND_CODE>
      <NAME>Naval Combatant</NAME>
      <NATIONALITY_CODE>UK</NATIONALITY_CODE>
      <OWNER_ID>1</OWNER_ID>
      <UPDATE_SEQNR>1</UPDATE_SEQNR>
    </OBJ_TYPE>
    <OBJ_TYPE>
      <OBJ_TYPE_ID>3806000000</OBJ_TYPE_ID>
      <CAT_CODE>OR</CAT_CODE>
      <DUMMY_IND_CODE>NO</DUMMY_IND_CODE>
      <NAME>Naval Combatant</NAME>
      <NATIONALITY_CODE>AS</NATIONALITY_CODE>
      <OWNER_ID>1</OWNER_ID>
      <UPDATE_SEQNR>1</UPDATE_SEQNR>
    </OBJ_TYPE>
    <OBJ_TYPE>
      <OBJ_TYPE_ID>3807000000</OBJ_TYPE_ID>
      <CAT_CODE>OR</CAT_CODE>
      <DUMMY_IND_CODE>NO</DUMMY_IND_CODE>
      <NAME>Unmanned Air Vehicle Squadron</NAME>
      <NATIONALITY_CODE>NZ</NATIONALITY_CODE>
      <OWNER_ID>1</OWNER_ID>
      <UPDATE_SEQNR>1</UPDATE_SEQNR>
    </OBJ_TYPE>
    <OBJ_TYPE>
      <OBJ_TYPE_ID>3808000000</OBJ_TYPE_ID>
      <CAT_CODE>OR</CAT_CODE>
      <DUMMY_IND_CODE>NO</DUMMY_IND_CODE>
      <NAME>Naval Combatant</NAME>
      <NATIONALITY_CODE>CA</NATIONALITY_CODE>
      <OWNER_ID>1</OWNER_ID>
      <UPDATE_SEQNR>1</UPDATE_SEQNR>
    </OBJ_TYPE>
    <OBJ_TYPE>
      <OBJ_TYPE_ID>3810000000</OBJ_TYPE_ID>
      <CAT_CODE>OR</CAT_CODE>
      <DUMMY_IND_CODE>NO</DUMMY_IND_CODE>
      <NAME>CTF Commander</NAME>
      <NATIONALITY_CODE>AS</NATIONALITY_CODE>
      <OWNER_ID>1</OWNER_ID>
      <UPDATE_SEQNR>1</UPDATE_SEQNR>
    </OBJ_TYPE>
  </OBJ_TYPE_TBL>
```

Figure 11 *The second part of the object-type table. This part of the table identifies the administrative and functional structures.*

4.1.8 Types of Materiel

The four classes or object types identified in Figure 10 are further expanded in Figure 12. The <MAT_TYPE_ID> links back to the <OBJ_TYPE_ID> from Figure 10. In all records shown for the MAT_TYPE *(materiel-type)* table, the *category-code* is "EQ" indicating equipment.

The remaining fields are blank, but should nevertheless be noted. The *reportable-item-text* (<RPTBL_ITEM_TXT>) references the Reportable Item Code list issued by NATO. The *stock-number-text* (<STOCK_NO_TXT>) represents the NATO stock number. The *supply-class-code* (<SUPPLY_CLASS_CODE>) represents the NATO class of the materiel [29, 30].

4.1.9 Types of Equipment

The EQPT_TYPE *(equipment-type)* table is shown in Figure 13. *Equipment-type* represents one entity in the incomplete specialization of the *materiel-type* entity – the other entity being *consumable-material-type* (not used in this experiment). The *equipment-type* is linked to the *materiel-type* via the relationship between <EQPT_TYPE_ID> and <MAT_TYPE_ID>. The *equipment-type* records indicate that the equipment is actually three vessels and an aircraft.

The *category-code* in the *equipment-type* table subdivides the equipment into more specific groups. The <CAT_CODE> of "VESSEL" is defined as "An EQUIPMENT-TYPE that is designed to operate on or under the water surface" [13] and thus includes a submarine. Recall that the submarine is indicated using <EQPT_TYPE_ID> of "3801000000". The loaded and unloaded weight of the equipment may be described in the *equipment-type* record, as well as height, width and length dimensions.

Equipment-type is further specified by a complete specialization in the ER logical model. The specializations include entities for aircraft, electronics, engineering, land weapons, nuclear-biological-chemical (NBC) equipment, railcars, vehicles, vessels and miscellaneous equipment.

```
<MAT_TYPE_TBL>
  <MAT_TYPE>
    <MAT_TYPE_ID>3800000000</MAT_TYPE_ID>
    <CAT_CODE>EQ</CAT_CODE>
    <RPTBL_ITEM_TXT></RPTBL_ITEM_TXT>
    <STOCK_NO_TXT></STOCK_NO_TXT>
    <SUPPLY_CLASS_CODE></SUPPLY_CLASS_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </MAT_TYPE>
  <MAT_TYPE>
    <MAT_TYPE_ID>3801000000</MAT_TYPE_ID>
    <CAT_CODE>EQ</CAT_CODE>
    <RPTBL_ITEM_TXT></RPTBL_ITEM_TXT>
    <STOCK_NO_TXT></STOCK_NO_TXT>
    <SUPPLY_CLASS_CODE></SUPPLY_CLASS_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </MAT_TYPE>
  <MAT_TYPE>
    <MAT_TYPE_ID>3802000000</MAT_TYPE_ID>
    <CAT_CODE>EQ</CAT_CODE>
    <RPTBL_ITEM_TXT></RPTBL_ITEM_TXT>
    <STOCK_NO_TXT></STOCK_NO_TXT>
    <SUPPLY_CLASS_CODE></SUPPLY_CLASS_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </MAT_TYPE>
  <MAT_TYPE>
    <MAT_TYPE_ID>3803000000</MAT_TYPE_ID>
    <CAT_CODE>EQ</CAT_CODE>
    <RPTBL_ITEM_TXT></RPTBL_ITEM_TXT>
    <STOCK_NO_TXT></STOCK_NO_TXT>
    <SUPPLY_CLASS_CODE></SUPPLY_CLASS_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </MAT_TYPE>
</MAT_TYPE_TBL>
```

Figure 12. The materiel-type table indicates the details of the materiel object types. The materiel objects are shown in Figure 10.

```
<EQPT_TYPE_TBL>
  <EQPT_TYPE>
    <EQPT_TYPE_ID>3800000000</EQPT_TYPE_ID>
    <CAT_CODE>VESSEL</CAT_CODE>
    <LOADED_WT_QTY></LOADED_WT_QTY>
    <UNLOADED_WT_QTY>0</UNLOADED_WT_QTY>
    <MAX_HEIGHT_DIM></MAX_HEIGHT_DIM>
    <MAX_LENGTH_DIM></MAX_LENGTH_DIM>
    <MAX_WIDTH_DIM></MAX_WIDTH_DIM>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </EQPT_TYPE>
  <EQPT_TYPE>
    <EQPT_TYPE_ID>3801000000</EQPT_TYPE_ID>
    <CAT_CODE>VESSEL</CAT_CODE>
    <LOADED_WT_QTY></LOADED_WT_QTY>
    <UNLOADED_WT_QTY>0</UNLOADED_WT_QTY>
    <MAX_HEIGHT_DIM></MAX_HEIGHT_DIM>
    <MAX_LENGTH_DIM></MAX_LENGTH_DIM>
    <MAX_WIDTH_DIM></MAX_WIDTH_DIM>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </EQPT_TYPE>
  <EQPT_TYPE>
    <EQPT_TYPE_ID>3802000000</EQPT_TYPE_ID>
    <CAT_CODE>AIRCFT</CAT_CODE>
    <LOADED_WT_QTY></LOADED_WT_QTY>
    <UNLOADED_WT_QTY>0</UNLOADED_WT_QTY>
    <MAX_HEIGHT_DIM></MAX_HEIGHT_DIM>
    <MAX_LENGTH_DIM></MAX_LENGTH_DIM>
    <MAX_WIDTH_DIM></MAX_WIDTH_DIM>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </EQPT_TYPE>
  <EQPT_TYPE>
    <EQPT_TYPE_ID>3803000000</EQPT_TYPE_ID>
    <CAT_CODE>VESSEL</CAT_CODE>
    <LOADED_WT_QTY></LOADED_WT_QTY>
    <UNLOADED_WT_QTY>0</UNLOADED_WT_QTY>
    <MAX_HEIGHT_DIM></MAX_HEIGHT_DIM>
    <MAX_LENGTH_DIM></MAX_LENGTH_DIM>
    <MAX_WIDTH_DIM></MAX_WIDTH_DIM>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </EQPT_TYPE>
</EQPT_TYPE_TBL>
```

Figure 13. The equipment-type table further specifics the materiel types. Note that the vessel's weight and dimensions could have been specified.

4.1.10 Vessels and Aircraft

Each identified piece of equipment is then described using the *vessel-type* or the *aircraft-type* tables (Figure 14). In both cases, the identifier (<VESSEL_TYPE_ID> or <ACFT_TYPE_ID>) is linked back to the EQPT_TYPE table. The <CAT_CODE> in Figure 13 determines the specialization.

In the *vessel_type* table, the <CAT_CODE> indicates if the vessel is a surface or subsurface unit. The "SUBSRF" indicates subsurface. The *subcategory-code* (<SUBCAT_CODE>) represents a specific class of vessel. A total of 61 *subcategory-codes* exist for vessel, including such diverse items such as barrage, raft, and tug boat. In this experiment, the data load includes "FRIGAT" and "SUBATT" indicating a Frigate and an attack submarine.

In the *aircraft-type* entity the *category-code* indicates a fixed wing aircraft. The *subcategory-code* indicates an UAV.

```
<VESSEL_TYPE_TBL>
  <VESSEL_TYPE>
    <VESSEL_TYPE_ID>3800000000</VESSEL_TYPE_ID>
    <CAT_CODE>SURFAC</CAT_CODE>
    <SUBCAT_CODE>FRIGAT</SUBCAT_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </VESSEL_TYPE>
  <VESSEL_TYPE>
    <VESSEL_TYPE_ID>3801000000</VESSEL_TYPE_ID>
    <CAT_CODE>SUBSRF</CAT_CODE>
    <SUBCAT_CODE>SUBATT</SUBCAT_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </VESSEL_TYPE>
  <VESSEL_TYPE>
    <VESSEL_TYPE_ID>3803000000</VESSEL_TYPE_ID>
    <CAT_CODE>SUBSRF</CAT_CODE>
    <SUBCAT_CODE>FRIGAT</SUBCAT_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </VESSEL_TYPE>
</VESSEL_TYPE_TBL>
<ACFT_TYPE_TBL>
  <ACFT_TYPE>
    <ACFT_TYPE_ID>3802000000</ACFT_TYPE_ID>
    <CAT_CODE>FIXWNG</CAT_CODE>
    <SUBCAT_CODE>UAV</SUBCAT_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </ACFT_TYPE>
</ACFT_TYPE_TBL>
```

Figure 14. The vessel and aircraft materiel objects are further specified by the complete specialization. In this case, the vessel-type and aircraft-type tables are used.

4.1.11 Types of Organisations

The *object-types* defined in Figure 11 dealt with organisation objects. These objects are further described using the ORG_TYPE *(organisation-type)* table shown in Figure 15.

The <ORG_TYPE_ID> provides the link back to the <OBJ_TYPE_ID> in Figure 11. Each organisation is identified using <CAT_CODE> as "GVTORG" which is defined in the data model as "An ORGANISATION-TYPE that controls and administers public policy either under a national or international mandate" [13].

4.1.12 Government Organisations

Each *organisation-type* was identified as government. These organisations are then further specified using the GOVT_ORG_TYPE *(government-organisation-type)* table (Figure 16). The <GOVT_ORG_TYPE_ID> is linked back to the <ORG_TYPE_ID>. In each record in Figure 16, the government organisation is identified as "MILORG" which is defined as "A GOVERNMENT-ORGANISATION-TYPE that is officially sanctioned and is trained and equipped to exert force" [13].

The <MAIN_ACTIVITY_CODE> describes the main function of the government organisation. This field is "NOS" representing "not otherwise specified".

```
<ORG_TYPE_TBL>
  <ORG_TYPE>
    <ORG_TYPE_ID>3805000000</ORG_TYPE_ID>
    <CAT_CODE>GVTORG</CAT_CODE>
    <DESCR_TXT>Naval Unit</DESCR_TXT>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </ORG_TYPE>
  <ORG_TYPE>
    <ORG_TYPE_ID>3806000000</ORG_TYPE_ID>
    <CAT_CODE>GVTORG</CAT_CODE>
    <DESCR_TXT>Naval Unit</DESCR_TXT>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </ORG_TYPE>
  <ORG_TYPE>
    <ORG_TYPE_ID>3807000000</ORG_TYPE_ID>
    <CAT_CODE>GVTORG</CAT_CODE>
    <DESCR_TXT>Naval Unit</DESCR_TXT>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </ORG_TYPE>
  <ORG_TYPE>
    <ORG_TYPE_ID>3808000000</ORG_TYPE_ID>
    <CAT_CODE>GVTORG</CAT_CODE>
    <DESCR_TXT>Naval Unit</DESCR_TXT>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </ORG_TYPE>
  <ORG_TYPE>
    <ORG_TYPE_ID>3810000000</ORG_TYPE_ID>
    <CAT_CODE>GVTORG</CAT_CODE>
    <DESCR_TXT>Coalition TF Commander</DESCR_TXT>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </ORG_TYPE>
</ORG_TYPE_TBL>
```

Figure 15. *The organisation-type table is part of the complete specialization structure under object-type.*

```
<GOVT_ORG_TYPE_TBL>
  <GOVT_ORG_TYPE>
    <GOVT_ORG_TYPE_ID>3805000000</GOVT_ORG_TYPE_ID>
    <CAT_CODE>MILORG</CAT_CODE>
    <MAIN_ACTIVITY_CODE>NOS</MAIN_ACTIVITY_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </GOVT_ORG_TYPE>
  <GOVT_ORG_TYPE>
    <GOVT_ORG_TYPE_ID>3806000000</GOVT_ORG_TYPE_ID>
    <CAT_CODE>MILORG</CAT_CODE>
    <MAIN_ACTIVITY_CODE>NOS</MAIN_ACTIVITY_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </GOVT_ORG_TYPE>
  <GOVT_ORG_TYPE>
    <GOVT_ORG_TYPE_ID>3807000000</GOVT_ORG_TYPE_ID>
    <CAT_CODE>MILORG</CAT_CODE>
    <MAIN_ACTIVITY_CODE>NOS</MAIN_ACTIVITY_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </GOVT_ORG_TYPE>
  <GOVT_ORG_TYPE>
    <GOVT_ORG_TYPE_ID>3808000000</GOVT_ORG_TYPE_ID>
    <CAT_CODE>MILORG</CAT_CODE>
    <MAIN_ACTIVITY_CODE>NOS</MAIN_ACTIVITY_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </GOVT_ORG_TYPE>
  <GOVT_ORG_TYPE>
    <GOVT_ORG_TYPE_ID>3810000000</GOVT_ORG_TYPE_ID>
    <CAT_CODE>MILORG</CAT_CODE>
    <MAIN_ACTIVITY_CODE>NOS</MAIN_ACTIVITY_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </GOVT_ORG_TYPE>
</GOVT_ORG_TYPE_TBL>
```

Figure 16. The government-organisation-type table is one table in an incomplete specialization of the organisation-type.

4.1.13 Military Organisations

The military organisations identified in Figure 16 are further detailed in Figure 17. The MIL_ORG_TYPE *(military-organisation-type)* table specifies that each military organisation may be considered a single unit, as indicated by the <CAT_CODE> of "UNIT". Other categories include the executive military organisation, task formation organisation, and a military posting. The military posting applies to a single person, while the other codes apply to groups.

The <SERVICE_CODE> represents the type of group that is considered the military organisation. The *service-code* definition is "The specific value that represents a military, paramilitary, or irregular force or group capable of functioning as an offensive or defensive combat or support organisation" [13]. The domain allows content including specifications for army, special forces, combined, joint, etc. For this VBE, this tag would be used to specify "NAVY" indicating that the particular military organisation belongs to the navy.

```
<MIL_ORG_TYPE_TBL>
  <MIL_ORG_TYPE>
    <MIL_ORG_TYPE_ID>3805000000</MIL_ORG_TYPE_ID>
    <CAT_CODE>UNIT</CAT_CODE>
    <SERVICE_CODE>NAVY</SERVICE_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </MIL_ORG_TYPE>
  <MIL_ORG_TYPE>
    <MIL_ORG_TYPE_ID>3806000000</MIL_ORG_TYPE_ID>
    <CAT_CODE>UNIT</CAT_CODE>
    <SERVICE_CODE>NAVY</SERVICE_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </MIL_ORG_TYPE>
  <MIL_ORG_TYPE>
    <MIL_ORG_TYPE_ID>3807000000</MIL_ORG_TYPE_ID>
    <CAT_CODE>UNIT</CAT_CODE>
    <SERVICE_CODE>NAVY</SERVICE_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </MIL_ORG_TYPE>
  <MIL_ORG_TYPE>
    <MIL_ORG_TYPE_ID>3808000000</MIL_ORG_TYPE_ID>
    <CAT_CODE>UNIT</CAT_CODE>
    <SERVICE_CODE>NAVY</SERVICE_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </MIL_ORG_TYPE>
  <MIL_ORG_TYPE>
    <MIL_ORG_TYPE_ID>3810000000</MIL_ORG_TYPE_ID>
    <CAT_CODE>MILPST</CAT_CODE>
    <SERVICE_CODE>NAVY</SERVICE_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </MIL_ORG_TYPE>
</MIL_ORG_TYPE_TBL>
```

Figure 17. The military-organisation-type table is the only table in the incomplete specialization of the government-organisation structure.

4.1.14 Types of Units

The UNIT_TYPE *(unit-type)* table (Figure 18) is defined as "A MILITARY-ORGANISATION-TYPE whose structure is prescribed by competent authority" [13]. This table assists in the specification of the *military-organisation-type* and the *equipment-type*.

The <UNIT_TYPE_ID> (Figure 18) is used to provide a link back to the <MIL_ORG_TYPE_ID> in Figure 17. Each <CAT_CODE> in the *unit-type* table contains "COMBAT", indicating that the unit is capable of firepower and destructive force in the battlespace. The <ARM_CAT_CODE> indicates the specific arm or branch of the unit that is being described. Possible arms include landing support, medical or reconnaissance. In this case, the arm is "NOS" or not otherwise specified.

The *arm-specialization-code* <ARM_SPCLSN_CODE> further divides the arm into specializations. The specializations may be branches such as dental, motorised or veterinary. In this case, the <ARM_SPCLSN_CODE> is "NAVAL" indicating that the unit is employed in the naval regime.

The *size-code* (<SIZE_CODE>) is defined as "The specific value that represents the relative size of the commonly accepted configuration of military formations" [13]. The "TSKEL" content indicates that the unit is organised for a specific task. The majority of allowed codes for <SIZE_CODE> are specific to the army. This is one area in the LC2IEDM where improvements could be made to encompass naval units.

The <PRINCIPAL_EQPT_TYPE_ID> provides a link to the <EQPT_TYPE_ID> in the *equipment-type* table (see Figure 13). The first record in Figure 18 indicates that the primary equipment of unit "3805000000" has <PRINCIPAL_EQPT_TYPE_ID> of "3800000000". Referring back to Figure 13, we see that <EQPT_TYPE_ID> of "3800000000" indicates a vessel. Thus, the military organisation unit identified by *unit-id* of "3805000000" has a vessel as its primary equipment.

The *supported-military-organisation-type-id* represents a link back to the MIL_ORG_TYPE table (Figure 17). The link allows specification of another military organisation that is supported by the unit. In this way, multiple units may support a larger structure or military organisation.

```
<UNIT_TYPE_TBL>
  <UNIT_TYPE>
    <UNIT_TYPE_ID>3805000000</UNIT_TYPE_ID>
    <CAT_CODE>COMBAT</CAT_CODE>
    <ARM_CAT_CODE>NOS</ARM_CAT_CODE>
    <ARM_SPCLSN_CODE>NAVAL</ARM_SPCLSN_CODE>
    <SIZE_CODE>TSKEL</SIZE_CODE>
    <PRINCIPAL_EQPT_TYPE_ID>3800000000</PRINCIPAL_EQPT_TYPE_ID>
    <SUPPORTED_MIL_ORG_TYPE_ID></SUPPORTED_MIL_ORG_TYPE_ID>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </UNIT_TYPE>
  <UNIT_TYPE>
    <UNIT_TYPE_ID>3806000000</UNIT_TYPE_ID>
    <CAT_CODE>COMBAT</CAT_CODE>
    <ARM_CAT_CODE>NOS</ARM_CAT_CODE>
    <ARM_SPCLSN_CODE>NAVAL</ARM_SPCLSN_CODE>
    <SIZE_CODE>TSKEL</SIZE_CODE>
    <PRINCIPAL_EQPT_TYPE_ID>3801000000</PRINCIPAL_EQPT_TYPE_ID>
    <SUPPORTED_MIL_ORG_TYPE_ID></SUPPORTED_MIL_ORG_TYPE_ID>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </UNIT_TYPE>
  <UNIT_TYPE>
    <UNIT_TYPE_ID>3807000000</UNIT_TYPE_ID>
    <CAT_CODE>COMBAT</CAT_CODE>
    <ARM_CAT_CODE>NOS</ARM_CAT_CODE>
    <ARM_SPCLSN_CODE>NAVAL</ARM_SPCLSN_CODE>
    <SIZE_CODE>TSKEL</SIZE_CODE>
    <PRINCIPAL_EQPT_TYPE_ID>3802000000</PRINCIPAL_EQPT_TYPE_ID>
    <SUPPORTED_MIL_ORG_TYPE_ID></SUPPORTED_MIL_ORG_TYPE_ID>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </UNIT_TYPE>
  <UNIT_TYPE>
    <UNIT_TYPE_ID>3808000000</UNIT_TYPE_ID>
    <CAT_CODE>COMBAT</CAT_CODE>
    <ARM_CAT_CODE>NOS</ARM_CAT_CODE>
    <ARM_SPCLSN_CODE>NAVAL</ARM_SPCLSN_CODE>
    <SIZE_CODE>TSKEL</SIZE_CODE>
    <PRINCIPAL_EQPT_TYPE_ID>3803000000</PRINCIPAL_EQPT_TYPE_ID>
    <SUPPORTED_MIL_ORG_TYPE_ID></SUPPORTED_MIL_ORG_TYPE_ID>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </UNIT_TYPE>
</UNIT_TYPE_TBL>
```

Figure 18. The unit-type table is one table in an incomplete specialization of the military-organisation-type.

4.1.15 Military Posting

The MIL_POST_TYPE *(military-post-type)* table identifies the duties of a particular person. For VBE-B, only the Coalition Task Force (CTF) Commander is identified. Note that the <CAT_CODE> of "AUTCDR" indicates an officer in charge of a unit, post, camp or operation. The <RANK_CODE> of "OF6" indicates an officer of rank Brigadier. The allowed content of <RANK_CODE> needs to be expanded to include naval personnel.

```
<MIL_POST_TYPE_TBL>
  <MIL_POST_TYPE>
    <MIL_POST_TYPE_ID>3810000000</MIL_POST_TYPE_ID>
    <CAT_CODE>AUTCDR</CAT_CODE>
    <RANK_CODE>OF6</RANK_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </MIL_POST_TYPE>
</MIL_POST_TYPE_TBL>
```

Figure 19. The military-post-type table describes a set of duties to be fulfilled by a particular person.

4.1.16 Reporting Data

The RPTD *(reporting-data)* table is shown in Figure 20. Each record in the *reporting-data* table represents a single report and may be considered similar to a report from a person or organisation. The information in this table is used to join or amalgamate information from other tables within the model.

The *reporting-data-id* (<RPTD_ID>) is a numeric identifier that provides links to other identifiers. The *accuracy-code* is intended to provide a general appraisal of the data composing the report. For example, the domain of the *accuracy-code* includes confirmed (1), probably (2), possible (3), doubtful (4), improbable (5), and truth cannot be judged (6) [13]. The data receiver would set the *accuracy-code*.

The *category-code* is described as "The specific value that represents, for usual operational purposes, the nature of a specific REPORTING-DATA" [13]. The domain values for *category-code* includes assumed, erroneous, inferred, planned, reported and restricted [13].

The <CNTG_IND_CODE> or *counting-indicator-code* indicates if the reported data is base on a count of objects. The domain is Yes and No [13].

The *credibility-code* (<CAT_CODE>) provides information on the trustworthiness of the data in the report. Domain values include indeterminate (IND), reported as a fact (RPTFCT), reported as plausible (RPTPLA) and reported as uncertain (RPTUNC). In

Figure 20, the report is noted to be "RPTFCT", or reported as fact. In the documentation, this domain value has a definition of "Data is reported by different sources whose integrity is not in question" [13].

Unfortunately this definition includes comment on the integrity of the source and not on the credibility of the reported data. The implication is that source integrity implies credible data. However, sources can be completely credible, while the reported data originating from the source is not credible. The distinction is easily understood by considering the justice system, which places considerable emphasis on eyewitness accounts of criminal activity. In 1996, the American Psychology and Law Society examined eyewitness identification of criminals and subsequently created guidelines for conducting police line-up identifications. The case study [31] examined 40 conviction cases that were later exonerated using DNA evidence. Of the 40 cases, 36 (90%) used eyewitness identification information that assisted the conviction.

Another problem is related to mixing of information within the attributes of the record. The *reliability-code* is an attribute that specifically deals with the source integrity. As such, the integrity comment in the RPTFCT definition should not be present in the *credibility-code* attribute, but rather solely contained in the *reliability-code*.

```
<RPTD_TBL>
  <RPTD>
    <RPTD_ID>4800000000</RPTD_ID>
    <ACCURACY_CODE>3</ACCURACY_CODE>
    <CAT_CODE>REP</CAT_CODE>
    <CNTG_IND_CODE>YES</CNTG_IND_CODE>
    <CREDIBILITY_CODE>RPTFCT</CREDIBILITY_CODE>
    <RELIABILITY_CODE>C</RELIABILITY_CODE>
    <REP_DATE>36517</REP_DATE>
    <REP_TIME>54000</REP_TIME>
    <SOURCE_TYPE_CODE>UNSPEC</SOURCE_TYPE_CODE>
    <TIMING_CAT_CODE>RDABST</TIMING_CAT_CODE>
    <REF_ID>1800000000</REF_ID>
    <REP_ORG_ID>2810000000</REP_ORG_ID>
    <ENT_CAT_CODE>ACTEFF</ENT_CAT_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </RPTD>
</RPTD_TBL>
```

Figure 20. The reporting-data table identifies reported information. Numerous codes help specify the information contained in the report.

The *reliability-code* judges the reported information source in terms of the likelihood that the source provides information that is free of error. The domain values include completely reliable (A), usually reliable (B), fairly reliable (C), not usually reliable (D), reliability cannot be judged (F), and unreliable (E) [13].

As the codes used within *reporting-data* are assembled, the potential for confusion amongst the codes becomes evident. Table 3 summarizes a potential set of codes to be used within *reporting-data*. The codes do not violate any *reporting-data* business rules yet clearly contradict one another. For example, the reported data is based on fact or observation (*category-code*), it is from different sources (*credibility-code*), the integrity of the source is not in question (*credibility-code*) and erroneous information cannot be produced (*reliability-code*), yet the information is probably erroneous (*accuracy-code*).

The attributes shown in Table 3 indicate a data dependency termed a functional dependency in relational database theory. A functional dependency exists between the set of attributes *category-code, credibility-code,* and *reliability-code*, and the *accuracy-code*. A functional dependency [32, 33, 34] occurs when the value in one field specifies the value in another field. In this case, the value of the set {*category-code, credibility-code, reliability-code*} specifies the field value for *accuracy-code*. In the Table 3 example, the values in the set would result in an *accuracy-code* value of "1" indicating, "confirmed" or "Reported data is confirmed by at least 3 independent sources" [13].

To avoid potential inconsistencies in the database as a result of this type of functional dependency, the data modeller can either introduce a business rule to remove the possibility of data such as that shown in Table 3 from being entered into the database, or can introduce an intersection table[3]. If a business rule is added, then developed interfaces to the database must ensure the proper implementation of the rule. As well, database administrators must ensure that any direct database manipulation of the data is consistent with the business rule. An intersection table is the preferred solution as this avoids the coding of business rules and maintains the content restriction to the database management software level, which then applies to all data access operations.

The *reporting-date* and *reporting-time* (Figure 20) fields refer to the date and time of data entry into the database. This is not the date and time of the reported data.

The *source-type-code* refers to the original source of information. The data in LC2IEDM must have originated from some other source of information, such as an email, a contact or human intelligence. This code specifies the source type. There are at present 23 source type codes.

---

[3] An intersection table would contain all valid combinations of attribute values. The data shown in Table 3 would not be present in the intersection table because it is not a valid combination of data.

Table 3. *Codes are used extensively within the reporting-data table. Some code values contradict other code values that can be used in the same record. For example, the codes shown below are valid in a single reporting-data record, but are contradictory.*

ATTRIBUTE	CODE	CODE DESCRIPTION
accuracy-code	5	Reported data shall be considered as probably erroneous.
category-code	REP	A REPORTING-DATA that points to data based on fact or observation.
credibility-code	RPTFCT	Data is reported by different sources whose integrity is not in question.
reliability-code	A	The source of the reported data can be considered as completely reliable, i.e. erroneous information cannot be produced.

The *timing-category-code* simply indicates if the time of the reported data is in absolute or relative time. An example of an absolute time would be a time at a specific hour, month, day, etc. An example of a relative time would be 10 hours after a defined absolute time.

The *reference-id* (<REF_ID>) and *reporting-organisation-id* (<REP_ORG_ID>) are numeric identifiers used in other tables in the LC2IEDM. The *reference-id* is used in the reference table (see Figure 3) and links the reported data to the referenced information source. The *reporting-organisation-id* is the only link to an external object as defined in LC2IEDM.

The *entity-category-code* (<ENT_CAT_CODE>, note that this is the assumed logical name) refers to the physical name of the referenced table. The definitions associated with *entity-category-code* are unclear [14], however, progress has been made on understanding this field.

The *entity-category-code* is directly related to the only business rule associated with the *reporting-data* table. The business rule [12] states that a *reporting-data* record may only refer to data in a single entity. The *entity-category-code* describes the name of the entity that the particular *reporting-data* record references. This allows the overlying software to quickly locate the data being referenced by the *reporting-data* record.

4.1.17 Timing of the Reported Data

The report in Figure 20 was noted to have an identifier of "4800000000". A similar identifier in the <RPTD_ABS_TIMING_RPTD_ID> (see Figure 21) provides the link between the two records. The data timing is then specified by an *effective-date* and

effective-time (e.g., <EFFCTV_DATE>). Note that this is the time corresponding to the data.

The precision of the time value is indicated by the <EFFCTV_TIME_PRECISION_CODE>. In this case a precision of "SECOND" indicates that the time value is known to the nearest second. The duration time for which the reported information applies, is specified in the <DUR> content.

The date value is indicated in Figure 21 using the number of days from January 1, 1970. This day format is compliant with the Version 4.0 Generic Hub documentation but is not consistent with Version 5 LC2IEDM documentation. The Version 5 documentation [12] indicates that date is to be specified as yymmdd, where yy indicates year, mm indicates month and dd indicates day.

The time (<EFFCTV_TIME>) is specified in seconds for the indicated day. The format for time is hhmmss where hh indicates hours, mm indicates minutes and ss indicates seconds.

```
<RPTD_ABS_TIMING_TBL>
  <RPTD_ABS_TIMING>
    <RPTD_ABS_TIMING_RPTD_ID>4800000000</RPTD_ABS_TIMING_RPTD_ID>
    <DUR>0</DUR>
    <EFFCTV_DATE>2452764</EFFCTV_DATE>
    <EFFCTV_TIME>54000</EFFCTV_TIME>
    <EFFCTV_TIME_PRECISION_CODE>SECOND</EFFCTV_TIME_PRECISION_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </RPTD_ABS_TIMING>
</RPTD_ABS_TIMING_TBL>
```

Figure 21. The reporting-data-absolute-timing table. This table stores the date and time applicable to the reported information.

4.1.18 Types of Objects

The OBJ_ITEM_TYPE *(object-item-type)* table applies a link between the particular object item and the object type. Recall that object items may be counted, and thus refer to specific objects. Object types are classes of objects.

The records for *object-item-type* are shown in Figure 22. The <OBJ_ITEM_ID> provides a link to the particular *object-item*, as shown in Figure 4. The value of "2800000000" indicates the TeKaha platform. The <OBJ_TYPE_ID> of "3800000000" indicates a Type45 platform from the UK (as shown in Figure 10).

The *object-item-type-index* (<OBJ_ITEM_TYPE_IX>) provides a counter for the reports on a single object that has a consistently defined type. For example, in a coalition setting multiple platforms may report on a single object item. The report may be from different sources, with varying credibility, but indicate the same typing for the object. The index would provide the ability to store this varied information.

The link to *reporting-data* is provided using <RPTD_ID>. The link provides considerable information as outlined in Section 4.1.16. For example, the link provides information on who reported the typing information, the credibility of the report, the date/time of the reported information, etc.

4.1.19 The Status of Objects

The OBJ_ITEM_STAT *(object-item-status)* table provides information on the current hostility and condition of the object item. The <OBJ_ITEM_ID> provides a link to the *object-item* table, as shown in Figure 4. Thus, the first record given in Figure 23 is for the TeKaha platform. The <OBJ_ITEM_STAT_IX> provides an index for the evolution of the objects status. The <CAT_CODE> indicates the category of the object, and should agree with the category indicated in Figure 4 for that object.

The *hostility-code* (<HSTLY_CODE>) represents the perceived hostility of the object. For the TeKaha, the hostility is denoted "AFR" which indicates assumed friendly. The *booby-trap-indicator-code* indicates if the object has been booby trapped.

Note that the *object-item-status* also contains a link to *reporting-data* via the <RPTD_ID>. This allows reports to enter the database that change the status of objects (e.g., the hostility of an object). This also allows the identification of the information source that changed the objec"s status.

```
<OBJ_ITEM_TYPE_TBL>
  <OBJ_ITEM_TYPE>
    <OBJ_ITEM_ID>2800000000</OBJ_ITEM_ID>
    <OBJ_TYPE_ID>3800000000</OBJ_TYPE_ID>
    <OBJ_ITEM_TYPE_IX>1</OBJ_ITEM_TYPE_IX>
    <RPTD_ID>4800000000</RPTD_ID>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_ITEM_TYPE>
  <OBJ_ITEM_TYPE>
    <OBJ_ITEM_ID>2801000000</OBJ_ITEM_ID>
    <OBJ_TYPE_ID>3801000000</OBJ_TYPE_ID>
    <OBJ_ITEM_TYPE_IX>1</OBJ_ITEM_TYPE_IX>
    <RPTD_ID>4800000000</RPTD_ID>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_ITEM_TYPE>
  <OBJ_ITEM_TYPE>
    <OBJ_ITEM_ID>2802000000</OBJ_ITEM_ID>
    <OBJ_TYPE_ID>3802000000</OBJ_TYPE_ID>
    <OBJ_ITEM_TYPE_IX>1</OBJ_ITEM_TYPE_IX>
    <RPTD_ID>4800000000</RPTD_ID>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_ITEM_TYPE>
  <OBJ_ITEM_TYPE>
    <OBJ_ITEM_ID>2803000000</OBJ_ITEM_ID>
    <OBJ_TYPE_ID>3803000000</OBJ_TYPE_ID>
    <OBJ_ITEM_TYPE_IX>1</OBJ_ITEM_TYPE_IX>
    <RPTD_ID>4800000000</RPTD_ID>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_ITEM_TYPE>
</OBJ_ITEM_TYPE_TBL>
```

Figure 22. The object-item-type table specifies the link between a particular object-item and an object-type.

```
<OBJ_ITEM_STAT_TBL>
  <OBJ_ITEM_STAT>
    <OBJ_ITEM_ID>2800000000</OBJ_ITEM_ID>
    <OBJ_ITEM_STAT_IX>1</OBJ_ITEM_STAT_IX>
    <CAT_CODE>MA</CAT_CODE>
    <HSTLY_CODE>AFR</HSTLY_CODE>
    <BOOBY_TRAP_IND_CODE>NO</BOOBY_TRAP_IND_CODE>
    <RPTD_ID>4800000000</RPTD_ID>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_ITEM_STAT>
  <OBJ_ITEM_STAT>
    <OBJ_ITEM_ID>2801000000</OBJ_ITEM_ID>
    <OBJ_ITEM_STAT_IX>1</OBJ_ITEM_STAT_IX>
    <CAT_CODE>MA</CAT_CODE>
    <HSTLY_CODE>AFR</HSTLY_CODE>
    <BOOBY_TRAP_IND_CODE>NO</BOOBY_TRAP_IND_CODE>
    <RPTD_ID>4800000000</RPTD_ID>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_ITEM_STAT>
  <OBJ_ITEM_STAT>
    <OBJ_ITEM_ID>2802000000</OBJ_ITEM_ID>
    <OBJ_ITEM_STAT_IX>1</OBJ_ITEM_STAT_IX>
    <CAT_CODE>MA</CAT_CODE>
    <HSTLY_CODE>AFR</HSTLY_CODE>
    <BOOBY_TRAP_IND_CODE>NO</BOOBY_TRAP_IND_CODE>
    <RPTD_ID>4800000000</RPTD_ID>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_ITEM_STAT>
  <OBJ_ITEM_STAT>
    <OBJ_ITEM_ID>2803000000</OBJ_ITEM_ID>
    <OBJ_ITEM_STAT_IX>1</OBJ_ITEM_STAT_IX>
    <CAT_CODE>MA</CAT_CODE>
    <HSTLY_CODE>AFR</HSTLY_CODE>
    <BOOBY_TRAP_IND_CODE>NO</BOOBY_TRAP_IND_CODE>
    <RPTD_ID>4800000000</RPTD_ID>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_ITEM_STAT>
</OBJ_ITEM_STAT_TBL>
```

Figure 23. The object-item-status table provides information on the hostility level of the object

It may be useful to visualize the table structure used thus far in the data model. This is shown in Figure 24. The figure shows the table names in uppercase characters above the table. A rectangular box illustrates a table. Column names and data types are indicted within the table. Primary keys are indicated as named columns above the horizontal separator line in the table. Below the separator line are non-key column names.

Figure 24. *The LC2IEDM Version 5.0 table structure used thus far in the data load. The colours (in the electronic version) may be ignored (on a black and white printed page, colour may be indicated by a dotted line). The rounded edge tables indicate dependent tables, while square edges indicate independent tables. Relationships are indicated using IDEF1X notation [35].*

Relationships are illustrated using the Integration Definition for Information Modelling (IDEF1X) notation [35]. This notation illustrates a relationship between tables as either a solid or dashed line. The solid line represents a relationship where the foreign key is part of the primary key in the child table (an identifying relationship). A dashed line represents a relationship where the foreign key is not part of the primary key in the child table (a non-identifying relationship). A solid black circle on the end of a line

indicates zero, one or more records. A diamond symbol on the end of a line indicates zero or one records. No symbol on the end of a line indicates one record. Finally, a red line and dot indicates a specialization.

Figure 24 illustrates the complicated relationships that exist within the small number of tables used thus far. Note that there are in total about 196 tables in the LC2IEDM. By understanding the relationships, one can better understand the load sequence presented in the previous figures. For example, a table with relationships indicated with circles (e.g., *unit-type*) must be filled after the parent tables at the other end of the relationship (e.g., *equipment-type* and *military-organisation-type*). As noted previously, the relationships in the LC2IEDM are enforced by the database, not by OCXS. Thus, the XML content must not violate any of these relationships or the database will issue an error that will manifest itself as an exception[4] from OCXS.

4.2 Initial Load – Red Force Data

Upon entering the area of operation, the coalition force has available certain red force information. For example, the coalition knows there are hostile frigates in the area of operation. This information can be loaded into the database as part of the initial load. The following section will describe the XML load for the information known at the beginning of the VBE.

4.2.1 Red Force Objects

The known red force objects in the area of operation are described in Figure 25. The figure indicates two materiel objects, named FFG1 and FFG2. The <CAT_CODE> indicates that these objects are "MA" meaning materiel. As such, the objects are further specified in Figure 26 in the *materiel* table. Both objects are noted to be "GREY" with no markings.

[4] An exception is an error condition that changes the normal flow of control in a software program.

```
<OBJ_ITEM_TBL>
  <OBJ_ITEM>
    <OBJ_ITEM_ID>1801000000</OBJ_ITEM_ID>
    <CAT_CODE>MA</CAT_CODE>
    <NAME>FFG1</NAME>
    <ALTN_IDENTIFIC_TXT>FFG1</ALTN_IDENTIFIC_TXT>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_ITEM>
  <OBJ_ITEM>
    <OBJ_ITEM_ID>1801000001</OBJ_ITEM_ID>
    <CAT_CODE>MA</CAT_CODE>
    <NAME>FFG2</NAME>
    <ALTN_IDENTIFIC_TXT>FFG2</ALTN_IDENTIFIC_TXT>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_ITEM>
</OBJ_ITEM_TBL>
```

Figure 25. *The red force object items are described using additional records in the object-item table. These records define two objects, both being FFGs.*

```
<MAT_TBL>
  <MAT>
    <MAT_ID>1801000000</MAT_ID>
    <SERIAL_NO_ID_TXT>FFG-1</SERIAL_NO_ID_TXT>
    <LOT_IDENTIFIC_TXT></LOT_IDENTIFIC_TXT>
    <BODY_COLOUR_CODE>GREY</BODY_COLOUR_CODE>
    <MARKING_CODE>NOS</MARKING_CODE>
    <MARKING_COLOUR_CODE>NOS</MARKING_COLOUR_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </MAT>
  <MAT>
    <MAT_ID>1801000001</MAT_ID>
    <SERIAL_NO_ID_TXT>FFG-2</SERIAL_NO_ID_TXT>
    <LOT_IDENTIFIC_TXT></LOT_IDENTIFIC_TXT>
    <BODY_COLOUR_CODE>GREY</BODY_COLOUR_CODE>
    <MARKING_CODE>NOS</MARKING_CODE>
    <MARKING_COLOUR_CODE>NOS</MARKING_COLOUR_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </MAT>
</MAT_TBL>
```

Figure 26. *The materiel table further specifies the red force objects. At the time of the initial load, the only known information on the red force objects is the colour of the platforms, that being grey.*

4.2.2 The Hostile Object Types

The *object-type* table indicates the class of the hostile platforms. The VBE experimental plan [8] indicates that hostile FFGs are in the area of operation and as such the data load assumes that there is one type of hostile platform. This is indicated by the single record in Figure 27. The figure indicates that the object is a materiel, as indicated by <CAT_CODE> of "MA". The name of the materiel is denoted "FRIGATE" and the nationality code of "OR" indicates "orange". Orange is a hypothetical LC2IEDM country specification that is used in war games [13].

```
<OBJ_TYPE_TBL>
  <OBJ_TYPE>
    <OBJ_TYPE_ID>1901000000</OBJ_TYPE_ID>
    <CAT_CODE>MA</CAT_CODE>
    <DUMMY_IND_CODE>NO</DUMMY_IND_CODE>
    <NAME>FRIGATE</NAME>
    <NATIONALITY_CODE>OR</NATIONALITY_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_TYPE>
</OBJ_TYPE_TBL>
```

Figure 27. The object-type table record for the hostile platforms. The object-type is similar to the class of the object. Both hostile frigates are noted to be the same type.

4.2.3 Hostile Materiel, Equipment and Vessel Types

The *object-type* in Figure 27 indicates the object is a materiel (see <CAT_CODE of "MA"). To further specify the materiel, the specialization table *materiel-type* is used. Further specializations for *equipment-type* and *vessel-type* are also included, and are all shown in Figure 28.

Figure 28 shows the records for the *materiel-type*, *equipment-type* and *vessel-type* for the hostile platforms. Since both platforms are a single frigate class, only one record is used to describe the characteristics of the class. The *materiel-type* record indicates that the materiel is in fact equipment. The *equipment-type* record further expands this to show the equipment has category code of "VESSEL". The weight and dimensions of the vessel are also given.

The *vessel-type* table details the vessel. Here, it is noted to be a surface frigate by the <CAT_CODE> of "SURFAC" and the <SUBCAT_CODE> of "FRIGAT".

```
<MAT_TYPE_TBL>
  <MAT_TYPE>
    <MAT_TYPE_ID>1901000000</MAT_TYPE_ID>
    <CAT_CODE>EQ</CAT_CODE>
    <RPTBL_ITEM_TXT></RPTBL_ITEM_TXT>
    <STOCK_NO_TXT></STOCK_NO_TXT>
    <SUPPLY_CLASS_CODE></SUPPLY_CLASS_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </MAT_TYPE>
</MAT_TYPE_TBL>
<EQPT_TYPE_TBL>
  <EQPT_TYPE>
    <EQPT_TYPE_ID>1901000000</EQPT_TYPE_ID>
    <CAT_CODE>VESSEL</CAT_CODE>
    <LOADED_WT_QTY>2500000</LOADED_WT_QTY>
    <UNLOADED_WT_QTY>0</UNLOADED_WT_QTY>
    <MAX_HEIGHT_DIM>45</MAX_HEIGHT_DIM>
    <MAX_LENGTH_DIM>125</MAX_LENGTH_DIM>
    <MAX_WIDTH_DIM>15</MAX_WIDTH_DIM>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </EQPT_TYPE>
</EQPT_TYPE_TBL>
<VESSEL_TYPE_TBL>
  <VESSEL_TYPE>
    <VESSEL_TYPE_ID>1901000000</VESSEL_TYPE_ID>
    <CAT_CODE>SURFAC</CAT_CODE>
    <SUBCAT_CODE>FRIGAT</SUBCAT_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </VESSEL_TYPE>
</VESSEL_TYPE_TBL>
```

Figure 28. The materiel-type, equipment-type and vessel-type tables further describe the hostile platforms.

4.2.4 The Hostile Objects

The hostile object items are now linked to the object types using the *object-item-type* table as shown in Figure 29. The <OBJ_ITEM_ID> indicates the frigates in Figure 25 while the single object type is described in Figure 27. Again, the *reporting-data-id* (Figure 29) is linked to the *reporting-data* table (Figure 20) to allow the typing to be linked to a specific report on the object.

```
<OBJ_ITEM_TYPE_TBL>
  <OBJ_ITEM_TYPE>
    <OBJ_ITEM_ID>1801000000</OBJ_ITEM_ID>
    <OBJ_TYPE_ID>1901000000</OBJ_TYPE_ID>
    <OBJ_ITEM_TYPE_IX>1</OBJ_ITEM_TYPE_IX>
    <RPTD_ID>4800000000</RPTD_ID>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_ITEM_TYPE>
  <OBJ_ITEM_TYPE>
    <OBJ_ITEM_ID>1801000001</OBJ_ITEM_ID>
    <OBJ_TYPE_ID>1901000000</OBJ_TYPE_ID>
    <OBJ_ITEM_TYPE_IX>1</OBJ_ITEM_TYPE_IX>
    <RPTD_ID>4800000000</RPTD_ID>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_ITEM_TYPE>
</OBJ_ITEM_TYPE_TBL>
```

Figure 29. The hostile object items and object type are linked in the object-item-type table.

4.2.5 The Status of Hostile Objects

The status of the hostile objects is described in the *object-item-status* table as shown in Figure 30. Each object item is shown to be a materiel, with hostility code "HO" indicating hostile. Neither hostile object is thought to be booby trapped, as indicated by the "NO" content in <BOOBY_TRAP_IND_CODE>.

```
<OBJ_ITEM_STAT_TBL>
  <OBJ_ITEM_STAT>
    <OBJ_ITEM_ID>1801000000</OBJ_ITEM_ID>
    <OBJ_ITEM_STAT_IX>1</OBJ_ITEM_STAT_IX>
    <CAT_CODE>MA</CAT_CODE>
    <HSTLY_CODE>HO</HSTLY_CODE>
    <BOOBY_TRAP_IND_CODE>NO</BOOBY_TRAP_IND_CODE>
    <RPTD_ID>4800000000</RPTD_ID>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_ITEM_STAT>
  <OBJ_ITEM_STAT>
    <OBJ_ITEM_ID>1801000001</OBJ_ITEM_ID>
    <OBJ_ITEM_STAT_IX>1</OBJ_ITEM_STAT_IX>
    <CAT_CODE>MA</CAT_CODE>
    <HSTLY_CODE>HO</HSTLY_CODE>
    <BOOBY_TRAP_IND_CODE>NO</BOOBY_TRAP_IND_CODE>
    <RPTD_ID>4800000000</RPTD_ID>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_ITEM_STAT>
</OBJ_ITEM_STAT_TBL>
```

Figure 30. The object-item-status table is used to describe the hostility level of the red force objects.

4.2.6 Using Context

A small section of the context load is shown in Figure 31 (full load shown in Annex 1). This context section shows a context record that identifies a surface radar. This equipment will be linked to a report in a later section of the XML.

```
<CONTXT>
  <CONTXT_ID>6800005000</CONTXT_ID>
  <NAME>Surface Search Radar</NAME>
  <OWNER_ID>1</OWNER_ID>
  <UPDATE_SEQNR>1</UPDATE_SEQNR>
</CONTXT>
```

Figure 31. A small part of the context table. One record is shown that will be used in the Solution Report. The full context load is shown in Annex 1.

4.3 Initial Load – Neutrals

The initial load of the neutrals follows the load sequence for the hostile units. The XML content for the neutrals is shown in Annex 1 (see section of Annex 1 marked with the comment <!-- Start Neutral Description -->).

Annex 1 indicates that the neutral object types are described and are noted to be materiel. Then, the *materiel-type* is used to indicate that the *materiel* may be considered equipment. The *equipment* is further refined to be a *vessel*. The *vessel-type* table indicates two types, a fishing vessel and a merchant vessel.

4.4 Loading a Discovered Contact

The XML data loads thus far have all dealt with preliminary information available to the task force prior to entering the area of operation. After entering the area of operation, the individual platforms can detect objects in their area of detection, and report these objects to a shared information location. The LC2IEDM acts as the shared information repository.

The VBE plan [8] indicated that coalition ships have radar capabilities, while the ownship submarine (Sheean) has radar and electronic support measures (ESM) available. As an example of a discovered platform, consider the TeKaha platform discovering a contact.

In the VBE environment, a discovery is made by a federate. In this example, we consider a radar contact. Radar contacts are "discovered" by the radar federate. Having made the discovery, the radar federate then reports the discovered contact to the High Level Architecture (HLA) Runtime Infrastructure (RTI) (see Figure 32). The RTI then informs the OCXS Gateway Federate of the new contact. The OCXS Gateway federate then generates the XML messages that describe the contact. These messages are then sent to the OCXS application server. The application server places the content into the LC2IEDM. The application server also informs Horizon of the additional contact. Horizon is the software environment that manages the track data and displays the tracks to an operator [9].

An example of an object discovery and the developed XML report is given in this section. The example is built from the coalition platform TeKaha discovering the merchant ship known as Merchant6.

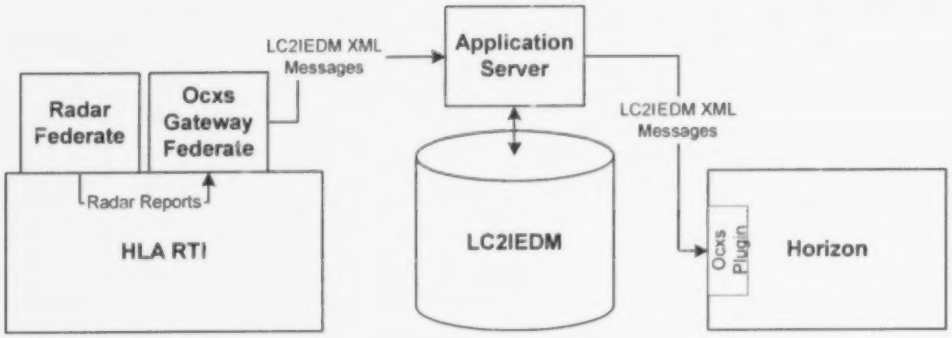

Figure 32. *The radar federate discovers the contact and informs the RTI. The RTI passes the data to the OCXS Gateway federate, which generates the XML and passes this to the OCXS Application Server. The Application Server places the data into the LC2IEDM. The Application Server also sends the XML message to the Horizon OCXS plugin. This informs Horizon of the new contact.*

4.4.1 The Contact Report

The knowledge of the contact is based on a report that is placed into the *reporting-data* table. The report is shown in Figure 33. This shows the report originates from *reporting-organisation-id* of "2805000000". This organisation is noted to be the FFH2 Command, as noted by Figure 5. As well, the command is known to exist on the platform with <OBJ_ITEM_ID> of "2800000000" as indicated by the *organisation-materiel-association* shown in Figure 9. This *object-item* is actually the TeKaha as indicted in Figure 4.

It should also be noted that OCXS has hard-coded the *entity-category-code* to "ACTEFF" [36]. The business rule for the *reporting-data* table indicates that the correct content in this case would be "OILOCA" representing the *object-item-location* record to be shown later in the XML (Figure 35). More discussion regarding the *reporting-data* business rule will follow in Section 4.4.4.

```
<?xml version='1.0' ?>
<GH5Complete xmlns:dt="urn:schemas-microsoft-com:datatypes">
  <RPTD_TBL>
    <RPTD>
      <RPTD_ID>-2147467264</RPTD_ID>
      <ACCURACY_CODE>3</ACCURACY_CODE>
      <CAT_CODE>REP</CAT_CODE>
      <CNTG_IND_CODE>YES</CNTG_IND_CODE>
      <CREDIBILITY_CODE>RPTFCT</CREDIBILITY_CODE>
      <RELIABILITY_CODE>C</RELIABILITY_CODE>
      <REP_DATE>00037579</REP_DATE>
      <REP_TIME>062214</REP_TIME>
      <SOURCE_TYPE_CODE>VARI</SOURCE_TYPE_CODE>
      <TIMING_CAT_CODE>RDABST</TIMING_CAT_CODE>
      <REF_ID>1800000000</REF_ID>
      <REP_ORG_ID>2805000000</REP_ORG_ID>
      <ENT_CAT_CODE>ACTEFF</ENT_CAT_CODE>
      <OWNER_ID>1</OWNER_ID>
      <UPDATE_SEQNR>1</UPDATE_SEQNR>
    </RPTD>
  </RPTD_TBL>
  <RPTD_ABS_TIMING_TBL>
    <RPTD_ABS_TIMING>
      <RPTD_ABS_TIMING_RPTD_ID>-2147467264</RPTD_ABS_TIMING_RPTD_ID>
      <DUR>0</DUR>
      <EFFCTV_DATE>00037579</EFFCTV_DATE>
      <EFFCTV_TIME>062209</EFFCTV_TIME>
      <EFFCTV_TIME_PRECISION_CODE>SECOND</EFFCTV_TIME_PRECISION_CODE>
      <OWNER_ID>1</OWNER_ID>
      <UPDATE_SEQNR>1</UPDATE_SEQNR>
    </RPTD_ABS_TIMING>
  </RPTD_ABS_TIMING_TBL>
```

Figure 33. The contact report takes the form of a record in the reporting-data table.

4.4.2 The Positional Information

To locate an object in space, the LC2IEDM must first have a position defined. Only after a position is defined, can an object be associated with that position. The first object to be positioned by the reported information is the reporting platform, the TeKaha.

To define a position or location in space, the LC2IEDM requires the LOC (*location*) table be filled with a unique identifier for the location. This is shown in Figure 34. The location given in Figure 34 indicates a point location via the <CAT_CODE> of "PT". This location is then expanded via the POINT (*point*) table. The link is obtained between the two tables via the <LOC_ID> and the <POINT_ID>.

The "ABS" <CAT_CODE> in the *point* table indicates the type of point, in this case an *absolute-point*.

```
<LOC_TBL>
  <LOC>
    <LOC_ID>-2147467263</LOC_ID>
    <CAT_CODE>PT</CAT_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </LOC>
</LOC_TBL>
<POINT_TBL>
  <POINT>
    <POINT_ID>-2147467263</POINT_ID>
    <CAT_CODE>ABS</CAT_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </POINT>
</POINT_TBL>
<VER_DIST_TBL>
  <VER_DIST>
    <VER_DIST_ID>-2147467263</VER_DIST_ID>
    <CAT_CODE>LOCSUR</CAT_CODE>
    <DIM>0</DIM>
    <PRECISION_CODE>10M</PRECISION_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </VER_DIST>
</VER_DIST_TBL>
<ABS_POINT_TBL>
  <ABS_POINT>
    <ABS_POINT_ID>-2147467263</ABS_POINT_ID>
    <LAT_COORD>34.2</LAT_COORD>
    <LONG_COORD>93.2</LONG_COORD>
    <ANGULAR_PRECISION_CODE>SECOND</ANGULAR_PRECISION_CODE>
    <ABS_POINT_VER_DIST_ID>-2147467263</ABS_POINT_VER_DIST_ID>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </ABS_POINT>
</ABS_POINT_TBL>
```

Figure 34. *The location of a point is defined, with the point being an absolute point at a specific latitude and longitude. The point is also noted to be at the sea surface.*

The *absolute-point* table is then used to define the actual spatial coordinates of the point. However, before filling the *absolute-point* table, the VER_DIST *(vertical-distance)* table must be filled. The *vertical-distance* table indicates via the <CAT_CODE> that the vertical describes the "LOCSUR" or location surface. This content is set by the OCXS Java class OcxsSolution [36].

The <DIM> field indicates the vertical dimension, which in this case is 0 m. Note that version 5.0 of the LC2IEDM defined the vertical distance as only positive, while version 6.0 should allow negative values in the dimension field. In this case, the 0 m dimension indicates a platform operating at sea level.

The ABS_POINT (*absolute-point*) table then links to the *point* and *vertical-distance* table. The link to *point* is obtained via the <ABS_POINT_ID> while the link to the *vertical-distance* table is obtained through the <ABS_POINT_VER_DIST_ID> field. In the present case, both of these XML elements contain the same content. The <PRECISION_CODE> in the *absolute-point* table indicates that the position is known to within one second of arc.

4.4.3 Linking TeKaha to a Position

The position of the TeKaha object is determined by relating the object to a location in space. In this case, the location was defined by the XML shown in Figure 34.

The *object-item-location* table is used to relate the object item and the location, as shown in Figure 35. The TeKaha is noted by the <OBJ_ITEM_ID> of "2800000000" (see Figure 4) and is linked to a location by the <LOC_ID> of "-2147467263" (see Figure 34). The TeKaha is noted to be on a course of 271.5° (noted by <BEARING_ANGLE>), and travelling at a speed of 5.6 km/hr, or about 3.0 knots. Note that the <RPTD_ID> has a value of "-2147467264". This report was shown in Figure 33. Again, the report allows one to identify the source and validity of information, as well as the date and time associated with the report.

```
<OBJ_ITEM_LOC_TBL>
  <OBJ_ITEM_LOC>
    <LOC_ID>-2147467263</LOC_ID>
    <OBJ_ITEM_ID>2800000000</OBJ_ITEM_ID>
    <OBJ_ITEM_LOC_IX>1</OBJ_ITEM_LOC_IX>
    <ACCURACY_QTY></ACCURACY_QTY>
    <BEARING_ANGLE>271.5</BEARING_ANGLE>
    <SPEED_RATE>5.6</SPEED_RATE>
    <GEOMETRY_CFEAT_TYPE_ID></GEOMETRY_CFEAT_TYPE_ID>
    <RPTD_ID>-2147467264</RPTD_ID>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_ITEM_LOC>
</OBJ_ITEM_LOC_TBL>
```

Figure 35. The link is established between the TeKaha object and the location point.

4.4.4 The Report

The second report in the XML message describes the reported information that pertains to Merchant6. The report, shown in Figure 36, indicates an accuracy of "3", which indicates that the reported information is "Possible" [13] and only from one source. The data in the report is based on facts, as indicated by the <CAT_CODE> of "REP". The *credibility-code* indicates that the report is based on fact, and is reported by different sources. The *reliability-code* indicates that the source is "fairly reliable".

The *reporting-data-date* and *reporting-data-time* are the date/time of the insertion into the database. The date is indicated by the number of days since January 1, 1970. This form follows the format for GH Version 4.0 (see Section 4.1.16.).

The *source-type-code* in the report indicates the type of source from which the information was obtained. In this report, the information is based on a contact and is indicated by "CONTAC". The *timing-category-code* indicates that the reported data time is absolute.

One problem with the OCXS report is related to the number of tables being referred to by the single *reporting-data* record. The business rule applicable to the *reporting-data* table specifies that a single *reporting-data* record should be used to refer to data in a single entity only [12]. The Solution Report load from OCXS violates this business rule, by loading records into many tables rather than only one table per *reporting-data* record. This Solution Report loads the tables *object-item-type*, *object-item-status* and *object-item-location*. There should be one *reporting-data* record for each of the records in these tables. Then, the *entity-category-code* for each of the *reporting-data* records would specify the particular table where the other insert has taken place.

```
<RPTD_TBL>
  <RPTD>
    <RPTD_ID>-2147467262</RPTD_ID>
    <ACCURACY_CODE>3</ACCURACY_CODE>
    <CAT_CODE>REP</CAT_CODE>
    <CNTG_IND_CODE>YES</CNTG_IND_CODE>
    <CREDIBILITY_CODE>RPTFCT</CREDIBILITY_CODE>
    <RELIABILITY_CODE>C</RELIABILITY_CODE>
    <REP_DATE>00037579</REP_DATE>
    <REP_TIME>062214</REP_TIME>
    <SOURCE_TYPE_CODE>CONTAC</SOURCE_TYPE_CODE>
    <TIMING_CAT_CODE>RDABST</TIMING_CAT_CODE>
    <REF_ID>1800000000</REF_ID>
    <REP_ORG_ID>2805000000</REP_ORG_ID>
    <ENT_CAT_CODE>ACTEFF</ENT_CAT_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </RPTD>
</RPTD_TBL>
<RPTD_ABS_TIMING_TBL>
  <RPTD_ABS_TIMING>
    <RPTD_ABS_TIMING_RPTD_ID>-2147467262</RPTD_ABS_TIMING_RPTD_ID>
    <DUR>0</DUR>
    <EFFCTV_DATE>00037579</EFFCTV_DATE>
    <EFFCTV_TIME>062209</EFFCTV_TIME>
    <EFFCTV_TIME_PRECISION_CODE>SECOND</EFFCTV_TIME_PRECISION_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </RPTD_ABS_TIMING>
</RPTD_ABS_TIMING_TBL>
```

Figure 36. The reporting-data record indicates that a contact has been obtained. The information related to the report quality characteristics are indicated in this record. The reporting-data-absolute-timing table indicates the time of the contact.

The reporting organisation is indicated with <REP_ORG_ID> and has a value of "2805000000". This ID is related back to Figure 8 that indicates that the reporting unit is "FFH2". Using Figure 9 and Figure 4, we can determine that the reporting platform is the TeKaha.

The *reporting-data-absolute-timing-effective-date* and *effective-time* (also shown in Figure 36) indicates the time pertaining to the reported information, not the time of data insertion into the database. Again, the date/time format follows Version 4.0 of the GH.

4.4.5 The Merchant 6 Object

As a newly discovered object, Merchant6 needs to be identified as an item within LC2IEDM. This is accomplished via the *object-item* table, as shown in Figure 37. The record indicates the name of the object as "TeKaha_Radar_01_Merchant6_2:2". This name could be simply "Merchant6". The *alternate-identification-text* in Figure 37 is also used to identify the fact that this is the eighth real world object identified in the experiment (recall there are two fishing vessels and six merchant vessels in the experiment).

The *materiel* table can also be used to further describe the discovered object (e.g., colour and markings). In the case of a radar contact, such information is not available.

```
<OBJ_ITEM_TBL>
  <OBJ_ITEM>
    <OBJ_ITEM_ID>-2147467259</OBJ_ITEM_ID>
    <CAT_CODE>MA</CAT_CODE>
    <NAME>TeKaha_Radar_01_Merchant6_2:2</NAME>
    <ALTN_IDENTIFIC_TXT>vRealWorldContact_8</ALTN_IDENTIFIC_TXT>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_ITEM>
</OBJ_ITEM_TBL>
<MAT_TBL>
  <MAT>
    <MAT_ID>-2147467259</MAT_ID>
    <SERIAL_NO_ID_TXT></SERIAL_NO_ID_TXT>
    <LOT_IDENTIFIC_TXT></LOT_IDENTIFIC_TXT>
    <BODY_COLOUR_CODE>NOS</BODY_COLOUR_CODE>
    <MARKING_CODE>NOS</MARKING_CODE>
    <MARKING_COLOUR_CODE>NOS</MARKING_COLOUR_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </MAT>
</MAT_TBL>
```

Figure 37. The Merchant6 object must be defined as an object within the LC2IEDM. The object-item table is used to define the physical object.

4.4.6 The Merchant 6 Type

The Merchant6 object was defined in Figure 37, but defining the object does not describe the object. The object is described using the *object-item-type* table as shown in Figure 38.

The *object-item-type* is linked to the *object-type* table content shown in Annex 1 (see section on neutrals). The XML content in Annex 1 describes a Merchant vessel of New Zealand nationality. The *object-item-type* table links the object to the type, thereby establishing the relation between the object named "TeKaha_Radar_01_Merchant6_2:2" and the Merchant class of vessel.

The status of the object is also described in Figure 38. The status, which is primarily for reporting the hostility level of the object, is reported as "AFR", or assumed friendly. Note that the <RPTD_ID> indicates the report from Figure 36. This linkage provides the source that reported the information.

```
<OBJ_ITEM_TYPE_TBL>
  <OBJ_ITEM_TYPE>
    <OBJ_ITEM_ID>-2147467259</OBJ_ITEM_ID>
    <OBJ_TYPE_ID>1901020000</OBJ_TYPE_ID>
    <OBJ_ITEM_TYPE_IX>1</OBJ_ITEM_TYPE_IX>
    <RPTD_ID>-2147467262</RPTD_ID>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_ITEM_TYPE>
</OBJ_ITEM_TYPE_TBL>
<OBJ_ITEM_STAT_TBL>
  <OBJ_ITEM_STAT>
    <OBJ_ITEM_ID>-2147467259</OBJ_ITEM_ID>
    <OBJ_ITEM_STAT_IX>1</OBJ_ITEM_STAT_IX>
    <CAT_CODE>MA</CAT_CODE>
    <HSTLY_CODE>AFR</HSTLY_CODE>
    <BOOBY_TRAP_IND_CODE>NO</BOOBY_TRAP_IND_CODE>
    <RPTD_ID>-2147467262</RPTD_ID>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_ITEM_STAT>
</OBJ_ITEM_STAT_TBL>
```

Figure 38. The object-item-type establishes the relationship between the object named Merchant6 and the type of object. The type of object was described in the initial load. See Annex 1 in the section for neutrals.

4.4.7 Defining an Elliptical Area of Uncertainty

The radar detection of Merchant6 is based on a radar contact. In this case, the contact will be described using an elliptical area of uncertainty. To describe the position in this way, the radar report must contain the necessary content to create the elliptical area in the LC2IEDM database.

The LC2IEDM elliptical definition is based on three points and a surface. The points define the centre of the ellipse, and the intersection of the major and minor axis with

the ellipse. The intersection points are known as the first and second conjugate points of the ellipse (see Figure 39).

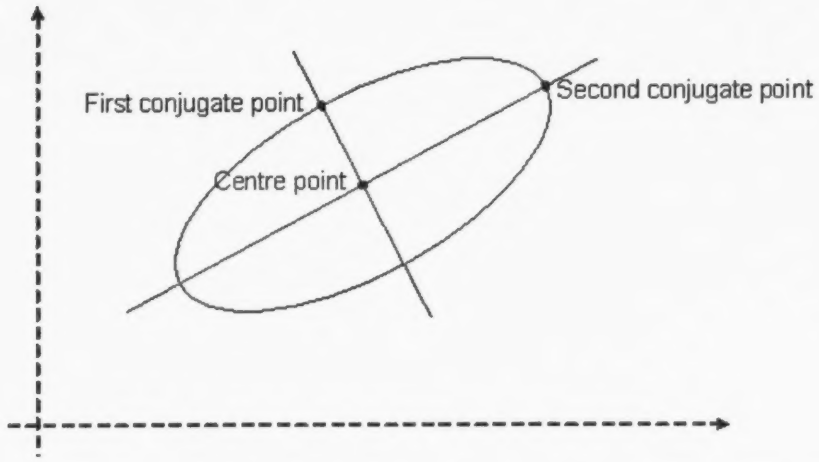

Figure 39. The elliptical shape is described using three points: the centre, and two points on the elliptical surface at the semi-major and semi-minor axes [12].

The elliptical area is defined using three points associated with the elliptical shape. To define the ellipse, the radar report first defines the centre of the ellipse. This location is defined by the XML tags as shown in Figure 40.

The <LOC_ID> shown in Figure 40 has an associated *absolute-point-id* that indicates a point at 35.5°N and 95.5°E. The *vertical-distance* table indicates a <CAT_CODE> of "LOCSUR" meaning "The datum for VERTICAL-DISTANCE provided by terrain or sea level at a point or area" [13]. The *precision-code* indicates we know the vertical position to within 10 m. This point will be used as the centre point of the elliptical area of uncertainty. The *point*, *vertical-distance* and *absolute-point* data is defined similarly to Figure 34.

```
<LOC_TBL>
  <LOC>
    <LOC_ID>-2147467260</LOC_ID>
    <CAT_CODE>PT</CAT_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </LOC>
</LOC_TBL>
<POINT_TBL>
  <POINT>
    <POINT_ID>-2147467260</POINT_ID>
    <CAT_CODE>ABS</CAT_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </POINT>
</POINT_TBL>
<VER_DIST_TBL>
  <VER_DIST>
    <VER_DIST_ID>-2147467260</VER_DIST_ID>
    <CAT_CODE>LOCSUR</CAT_CODE>
    <DIM>0</DIM>
    <PRECISION_CODE>10M</PRECISION_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </VER_DIST>
</VER_DIST_TBL>
<ABS_POINT_TBL>
  <ABS_POINT>
    <ABS_POINT_ID>-2147467260</ABS_POINT_ID>
    <LAT_COORD>35.5</LAT_COORD>
    <LONG_COORD>95.5</LONG_COORD>
    <ANGULAR_PRECISION_CODE>SECOND</ANGULAR_PRECISION_CODE>
    <ABS_POINT_VER_DIST_ID>-2147467260</ABS_POINT_VER_DIST_ID>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </ABS_POINT>
</ABS_POINT_TBL>
```

Figure 40. *The first position is described for what will be defined as the centre point of the elliptical area of uncertainty. This will be used to locate the radar contact for the Merchant6 vessel.*

Next, we define three additional locations: two points and a surface as shown in Figure 41. The points are located on the elliptical surface and thus will be used as the first and second conjugate points. In Figure 41, the points are indicated by the <CAT_CODE> of "PT" while the surface is indicated by "SURFAC".

```
<LOC_TBL>
  <LOC>
    <LOC_ID>-2147467258</LOC_ID>
    <CAT_CODE>PT</CAT_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </LOC>
  <LOC>
    <LOC_ID>-2147467257</LOC_ID>
    <CAT_CODE>PT</CAT_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </LOC>
  <LOC>
    <LOC_ID>-2147467256</LOC_ID>
    <CAT_CODE>SURFAC</CAT_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </LOC>
</LOC_TBL>
```

Figure 41. The location table defines two additional points and a surface. These will be used to describe an elliptical surface.

The two points are described in Figure 42. The vertical distance of these two points is noted to be zero metres in the *vertical-distance* table. This indicates that the points are on the sea surface. The two points are noted to be absolute, by the <CAT_CODE> in the point records (see Figure 42). The *absolute-point* table (Figure 43) then describes the two points as being located at 35.6°N, 95.5°W and 35.5°N, 98.5°W.

```
<POINT_TBL>
  <POINT>
    <POINT_ID>-2147467258</POINT_ID>
    <CAT_CODE>ABS</CAT_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </POINT>
  <POINT>
    <POINT_ID>-2147467257</POINT_ID>
    <CAT_CODE>ABS</CAT_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </POINT>
</POINT_TBL>

<VER_DIST_TBL>
  <VER_DIST>
    <VER_DIST_ID>-2147467258</VER_DIST_ID>
    <CAT_CODE>LOCSUR</CAT_CODE>
    <DIM>0</DIM>
    <PRECISION_CODE>10M</PRECISION_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </VER_DIST>
  <VER_DIST>
    <VER_DIST_ID>-2147467257</VER_DIST_ID>
    <CAT_CODE>LOCSUR</CAT_CODE>
    <DIM>0</DIM>
    <PRECISION_CODE>10M</PRECISION_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </VER_DIST>
</VER_DIST_TBL>
```

Figure 42. *The two points for the elliptical surface are described using the point table. The vertical-distance table describes the vertical position of the two points. Both points are at the sea surface.*

```
<ABS_POINT_TBL>
  <ABS_POINT>
    <ABS_POINT_ID>-2147467258</ABS_POINT_ID>
    <LAT_COORD>35.6</LAT_COORD>
    <LONG_COORD>95.5</LONG_COORD>
    <ANGULAR_PRECISION_CODE>SECOND</ANGULAR_PRECISION_CODE>
    <ABS_POINT_VER_DIST_ID>-2147467258</ABS_POINT_VER_DIST_ID>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </ABS_POINT>
  <ABS_POINT>
    <ABS_POINT_ID>-2147467257</ABS_POINT_ID>
    <LAT_COORD>35.5</LAT_COORD>
    <LONG_COORD>98.5</LONG_COORD>
    <ANGULAR_PRECISION_CODE>SECOND</ANGULAR_PRECISION_CODE>
    <ABS_POINT_VER_DIST_ID>-2147467257</ABS_POINT_VER_DIST_ID>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </ABS_POINT>
</ABS_POINT_TBL>
```

Figure 43. *The absolute-point table is used to describe two points in latitude-longitude space. These points will be used to define the elliptical surface for the Merchant6 contact.*

The surface of the area of uncertainty is then defined using the SURFACE (*surface*) table as shown in Figure 44. The surface <CAT_CODE> indicates that the defined surface is an ellipse. The <SURFACE_ID> refers back to the <LOC_ID> from Figure 41.

```
<SURFACE_TBL>
  <SURFACE>
    <SURFACE_ID>-2147467256</SURFACE_ID>
    <CAT_CODE>ELLPSE</CAT_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </SURFACE>
</SURFACE_TBL>
```

Figure 44. *The surface table defines an elliptical surface.*

The ellipse is described as in Figure 45. The centre point of the ellipse is noted to be point "-2147467260". Recall that this point is located at 35.5°N, 95.5°W as indicated by Figure 40. The first conjugate axis is noted to be point "-2147467258" while the second conjugate point has ID "-2147467257".

```
  <ELPS_TBL>
    <ELPS>
      <ELPS_ID>-2147467256</ELPS_ID>
      <ELPS_CENTRE_POINT_ID>-2147467260</ELPS_CENTRE_POINT_ID>
      <ELPS_FIRST_CNJG_DIAM_POINT_ID>-2147467258
</ELPS_FIRST_CNJG_DIAM_POINT_ID>
      <ELPS_SCND_CNJG_DIAM_POINT_ID>-2147467257
</ELPS_SCND_CNJG_DIAM_POINT_ID>
      <OWNER_ID>1</OWNER_ID>
      <UPDATE_SEQNR>1</UPDATE_SEQNR>
    </ELPS>
  </ELPS_TBL>
```

Figure 45. The elliptical shape is described in the ellipse table. The record refers to the three points used to define the ellipse.

4.4.8 Positioning Merchant 6 in the Area of Uncertainty

The final step is to associate the ellipse with the object. This is completed using the *object-item-location* table as shown in Figure 46. The <LOC_ID> of "-2147467256" relates to the <LOC_ID> in Figure 41, which in turn links to the <SURFACE_ID> in Figure 44. This table is also used to describe the present bearing and speed of the object, in this case Merchant6. The speed value of 12.34 km/hr corresponds to 6.66 knots.

```
  <OBJ_ITEM_LOC_TBL>
    <OBJ_ITEM_LOC>
      <LOC_ID>-2147467256</LOC_ID>
      <OBJ_ITEM_ID>-2147467259</OBJ_ITEM_ID>
      <OBJ_ITEM_LOC_IX>1</OBJ_ITEM_LOC_IX>
      <ACCURACY_QTY></ACCURACY_QTY>
      <BEARING_ANGLE>45.6</BEARING_ANGLE>
      <SPEED_RATE>12.34</SPEED_RATE>
      <GEOMETRY_CFEAT_TYPE_ID></GEOMETRY_CFEAT_TYPE_ID>
      <RPTD_ID>-2147467262</RPTD_ID>
      <OWNER_ID>1</OWNER_ID>
      <UPDATE_SEQNR>1</UPDATE_SEQNR>
    </OBJ_ITEM_LOC>
  </OBJ_ITEM_LOC_TBL>
</GH5Complete>
```

Figure 46. The object item for the Merchant6 vessel is linked to the location-id corresponding to the elliptical surface. The bearing and speed of the object is also given.

4.4.9 Placing it in Context

The final part of the Solution Report is the *context* (Figure 47). The present usage of the *context* table relates a *reporting-data* record to a *context* record (see Figure 31) established in the initial load. Figure 47 establishes the link between the *context-id* and the *reporting-data-id*. The intent of this link is to indicate that the *reporting-data* information was obtained via a surface radar, as indicated by the *context* table in Figure 31.

```
<CONTXT_RPTD_ASSOC_TBL>
  <CONTXT_RPTD_ASSOC>
    <CONTXT_ID>6800005000</CONTXT_ID>
    <RPTD_ID>-2147467262</RPTD_ID>
    <CONTXT_RPTD_ASSOC_IX>1</CONTXT_RPTD_ASSOC_IX>
    <CAT_CODE>ISDFT</CAT_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </CONTXT_RPTD_ASSOC>
</CONTXT_RPTD_ASSOC_TBL>
```

Figure 47. The context and reporting-data relationship is established via the context-reporting-data-association table.

5. Concluding Remarks

This report has documented the details of the data load into the LC2IEDM during VBE-B. Although the content of the data load is specific to VBE-B, the procedure followed and the type of data loaded applies to many naval tracking operations, not just a Virtual Battle Experiment.

During the writing of this report, considerable knowledge was gained by the authors on an assortment of topics. By actually placing data into the LC2IEDM, we further familiarized ourselves with the details of the entities and relationships within the data model. However, the report has highlighted many inconsistencies and possible inadequacies in the components used during the data load. These issues may be grouped into three categories: the LC2IEDM data model, the LC2IEDM documentation and the OCXS software package.

Based on the authors' current level of understanding, several recommendations are provided that would alleviate problems with the data model. For example:

- Multiple codes in a single record often leads to inappropriate code combinations. The combination of codes in the record, which can be considered a concatenation of codes, may not represent something that is consistent.

  An example of this problem is present in the *reporting-data* record. Code combinations can exist which do not provide consistent information (see Table 3). Creating business rules or possibly table restructuring to include an intersection table can reduce this problem. Both the business rule and intersection table would act to restrict the code to reasonable combinations in the *reporting-data* table.

- Within the LC2IEDM there often appears to be multiple solutions to a single data entry problem. In other words, a single set of data can rationally be placed in different tables or groups of tables. This problem is similar to organising a filing cabinet, where a file labelled "Mission Orders" may rationally be filed under "M" for Mission or "O" for Orders. An example within the LC2IEDM is the use of *context* to group objects, and the possible use of *organisation* or *holdings* to perform the same function.

This investigation has also highlighted potential problems with the LC2IEDM documentation. In some cases, the LC2IEDM documentation should be critically examined and clarified. The following issues were noted during this investigation.

- There are many examples where the code intent and the definition of a particular code value appear to diverge. To fully understand this, one needs to recognise the subtle differences between the field, the code, and the corresponding field and code definitions. As the container, the field is labelled

with a name that is related to the field definition. The field definition provides a description of the functional purpose of the field. (i.e. what the field should be used for). The code represents the content for the field, and is typically an abbreviated set of characters that represent an agreed upon definition. A problem develops when the code definition does not correspond to the field definition. In these cases, the code may be used to store information not originally intended as per the field definition.

As an example of this, consider the table *reporting-data* and the field *credibility-code*. The *credibility-code* is intended to store a statement on the trustworthiness of the reported data. However, a possible code for this field is "RPTFCT" which indicates the data is "reported by different sources whose integrity is not in question" [13]. There are two problems within this example. First, the field, as indicated by the definition, is not intended to store information on the number of sources. Second, the field is not intended to store information on the integrity of the sources. Indeed, the integrity of the source is contained in a separate field.

Although some may consider this to be a minor point, in any interoperable solution it is critically important that all parties know where to find the required information. Any conflicts in definitions leave open the possibility of information confusion.

- As the LC2IEDM moves toward joint use, many code lists will need to include the naval perspective. This applies to various code lists utilized during this investigation (e.g. *unit-type-size-code* and *military-post-type-rank-code*).

The Operational Context Exchange Service (OCXS) was utilized in this investigation. OCXS is the software package that provides an interface from outside applications to the LC2IEDM structure. The OCXS needs to evolve, and in particular the following issues need to be addressed:

- OCXS needs to accommodate the next official version of LC2IEDM. Considerable changes have taken place since version 5, which is currently the LC2IEDM supported by OCXS. By remaining current, OCXS may also be able to influence the evolution of the data model, and thereby better meet the needs of the navy.

- OCXS needs to implement the business rules in the model specification. In particular, the business rule associated with *reporting-data* should be implemented. This would provide researchers with a more accurate representation of information storage within the LC2IEDM.

- OCXS documentation needs to be developed. Documentation is essential for any software package that provides a service to users with a wide range of abilities. Efforts are underway to develop the required documentation [36],

but a more focused effort would expedite the process and improve the overall product.

As we look toward future VBE scenarios, a wealth of opportunity exists for exercising the LC2IEDM. The experiments provide an excellent forum for the naval assessment of the data model, and as the experiments move toward more realistic simulations other aspects of the model can be exercised. For example, the VBEs could use the planning section of the model for mission orders or platform tasking. In this case, the experiment could investigate not only the technical aspect of data sharing, but also the human aspect, such as operator responses to varied mission planning by another platform.

As TTCP MAR TP – 1 moves forward with VBE investigations, researchers hope to continue the collaborative investigations on naval information sharing. This research will focus on the details of *what* information is shared and on the mechanics of *how* the information is shared. Only by understanding both aspects, will researchers be able to contribute to naval information solutions in a networked environment.

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Annex 1: Initial XML Load for VBE-B

```
<?xml version='1.0' ?>
<GH5Complete xmlns:dt="urn:schemas-microsoft-com:datatypes">

  <REF_TBL>
    <REF>
      <REF_ID>1800000000</REF_ID>
      <FORMAT_CODE>NOS</FORMAT_CODE>
      <DESCR_TXT>MAR TP-1 VBE-B OCXS Data Fill</DESCR_TXT>
      <SECURITY_CLSFC_CODE>NU</SECURITY_CLSFC_CODE>
      <SOURCE_TXT>Scenario 1.xml</SOURCE_TXT>
      <TRANS_TYPE_CODE>EMLMSG</TRANS_TYPE_CODE>
      <OWNER_ID>1</OWNER_ID>
      <UPDATE_SEQNR>1</UPDATE_SEQNR>
    </REF>
  </REF_TBL>

  <OBJ_ITEM_TBL>
    <OBJ_ITEM>
      <OBJ_ITEM_ID>2800000000</OBJ_ITEM_ID>
      <CAT_CODE>MA</CAT_CODE>
      <NAME>TeKaha</NAME>
      <ALTN_IDENTIFIC_TXT></ALTN_IDENTIFIC_TXT>
      <OWNER_ID>1</OWNER_ID>
      <UPDATE_SEQNR>1</UPDATE_SEQNR>
    </OBJ_ITEM>
    <OBJ_ITEM>
      <OBJ_ITEM_ID>2801000000</OBJ_ITEM_ID>
      <CAT_CODE>MA</CAT_CODE>
      <NAME>Sheean</NAME>
      <ALTN_IDENTIFIC_TXT></ALTN_IDENTIFIC_TXT>
      <OWNER_ID>1</OWNER_ID>
      <UPDATE_SEQNR>1</UPDATE_SEQNR>
    </OBJ_ITEM>
    <OBJ_ITEM>
      <OBJ_ITEM_ID>2802000000</OBJ_ITEM_ID>
      <CAT_CODE>MA</CAT_CODE>
      <NAME>UAV</NAME>
      <ALTN_IDENTIFIC_TXT></ALTN_IDENTIFIC_TXT>
      <OWNER_ID>1</OWNER_ID>
      <UPDATE_SEQNR>1</UPDATE_SEQNR>
    </OBJ_ITEM>
    <OBJ_ITEM>
      <OBJ_ITEM_ID>2803000000</OBJ_ITEM_ID>
      <CAT_CODE>MA</CAT_CODE>
      <NAME>Halifax</NAME>
      <ALTN_IDENTIFIC_TXT></ALTN_IDENTIFIC_TXT>
      <OWNER_ID>1</OWNER_ID>
```

```
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_ITEM>
  <OBJ_ITEM>
    <OBJ_ITEM_ID>2805000000</OBJ_ITEM_ID>
    <CAT_CODE>OR</CAT_CODE>
    <NAME>FFH2 Command</NAME>
    <ALTN_IDENTIFIC_TXT></ALTN_IDENTIFIC_TXT>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_ITEM>
  <OBJ_ITEM>
    <OBJ_ITEM_ID>2806000000</OBJ_ITEM_ID>
    <CAT_CODE>OR</CAT_CODE>
    <NAME>Sheean Command</NAME>
    <ALTN_IDENTIFIC_TXT></ALTN_IDENTIFIC_TXT>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_ITEM>
  <OBJ_ITEM>
    <OBJ_ITEM_ID>2807000000</OBJ_ITEM_ID>
    <CAT_CODE>OR</CAT_CODE>
    <NAME>UAV Command</NAME>
    <ALTN_IDENTIFIC_TXT></ALTN_IDENTIFIC_TXT>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_ITEM>
  <OBJ_ITEM>
    <OBJ_ITEM_ID>2808000000</OBJ_ITEM_ID>
    <CAT_CODE>OR</CAT_CODE>
    <NAME>FFH1 Command</NAME>
    <ALTN_IDENTIFIC_TXT></ALTN_IDENTIFIC_TXT>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_ITEM>
  <OBJ_ITEM>
    <OBJ_ITEM_ID>2810000000</OBJ_ITEM_ID>
    <CAT_CODE>OR</CAT_CODE>
    <NAME>TP-1 Coalition Commander</NAME>
    <ALTN_IDENTIFIC_TXT></ALTN_IDENTIFIC_TXT>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </OBJ_ITEM>
</OBJ_ITEM_TBL>

<MAT_TBL>
  <MAT>
    <MAT_ID>2800000000</MAT_ID>
    <SERIAL_NO_ID_TXT></SERIAL_NO_ID_TXT>
    <LOT_IDENTIFIC_TXT></LOT_IDENTIFIC_TXT>
    <BODY_COLOUR_CODE>GREY</BODY_COLOUR_CODE>
    <MARKING_CODE>NOS</MARKING_CODE>
    <MARKING_COLOUR_CODE>NOS</MARKING_COLOUR_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
```

```
  </MAT>
  <MAT>
    <MAT_ID>2801000000</MAT_ID>
    <SERIAL_NO_ID_TXT></SERIAL_NO_ID_TXT>
    <LOT_IDENTIFIC_TXT></LOT_IDENTIFIC_TXT>
    <BODY_COLOUR_CODE>BLACK</BODY_COLOUR_CODE>
    <MARKING_CODE>NOS</MARKING_CODE>
    <MARKING_COLOUR_CODE>NOS</MARKING_COLOUR_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </MAT>
  <MAT>
    <MAT_ID>2802000000</MAT_ID>
    <SERIAL_NO_ID_TXT></SERIAL_NO_ID_TXT>
    <LOT_IDENTIFIC_TXT></LOT_IDENTIFIC_TXT>
    <BODY_COLOUR_CODE>WHITE</BODY_COLOUR_CODE>
    <MARKING_CODE>NOS</MARKING_CODE>
    <MARKING_COLOUR_CODE>NOS</MARKING_COLOUR_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </MAT>
  <MAT>
    <MAT_ID>2803000000</MAT_ID>
    <SERIAL_NO_ID_TXT></SERIAL_NO_ID_TXT>
    <LOT_IDENTIFIC_TXT></LOT_IDENTIFIC_TXT>
    <BODY_COLOUR_CODE>GREY</BODY_COLOUR_CODE>
    <MARKING_CODE>NOS</MARKING_CODE>
    <MARKING_COLOUR_CODE>NOS</MARKING_COLOUR_CODE>
    <OWNER_ID>1</OWNER_ID>
    <UPDATE_SEQNR>1</UPDATE_SEQNR>
  </MAT>
</MAT_TBL>

<ORG_TBL>
  <ORG>
    <ORG_ID>2805000000</ORG_ID>
    <CAT_CODE>UN</CAT_CODE>
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Annex 2: Solution Report Load on Discovered Radar Contact

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List of symbols/abbreviations/acronyms/initialisms

API	Application Programming Interface
ATCCIS	Army Tactical Command and Control Information System
AS	Australia
C2IEDM	Command and Control Information Exchange Data Model
C2IS	Command and Control Information System
CA	Canada
Comms	Communications
CTF	Coalition Task Force
DND	Department of National Defence
DRDC	Defence R&D Canada
DSL	Data Services Layer
ER	Entity – Relationship
ESM	Electronic Support Measures
FFH	Frigate, Helicopter
FFG	Guided Missile Frigate
GH	Generic Hub
HLA	High Level Architecture
JDBC	Java Database Connectivity
LC2IEDM	Land Command and Control Information Exchange Data Model
MAR	Maritime Systems Group
NBC	Nuclear-Biological-Chemical
NEC	Network Enabled Capability

NCW	Net Centric Warfare
NUW	Networked Underwater Warfare
NUWC	Naval Undersea Warfare Center
NZ	New Zealand
OCXS	Operational Context Exchange Service
RTI	Runtime Infrastructure
SAX	Simple API for XML
SQL	Structured Query Language
TF	Task Force
TP-1	Technical Panel – One
TTCP	The Technical Cooperation Program
UAV	Unmanned Aerial Vehicle
UK	United Kingdom
US	United States
VBE	Virtual Battle Experiment
VBE-B	Virtual Battle Experiment - Bravo
XML	eXtensible Markup Language
XSLT	eXtensible Stylesheet Language Transformations

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Land Command and Control Information Exchange Data Model
LC2IEDM
Virtual Battle Experiment
VBE
Operational Context Exchange Service
OCXS

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